VOLUME TWO

The AMERICAN CYCLOPEDIA of the AUTOMOBILE

or, MOTOR CARS and MOTORING SELF-TAUGHT

A WORK OF REFERENCE & SELF INSTRUCTION, COVERING the ENTIRE FIELD OF AUTOMOBILING. FOR OWNERS, REPAIR MEN, OPERATORS, INTENDING PURCHASERS & ALL OTHERS INTERESTED IN MOTORING OR the AUTOMOBILE TRADE

Profusely Illustrated

THE TEXT INCLUDES HUNDREDS of HINTS ON MOTOR & OTHER TROUBLES & THEIR REMEDIES .... ROADSIDE REPAIRS, ETC. STUDY HELPS & a COMPLETE CATECHISM on IMPORTANT SUBJECTS .. A HISTORY of the AUTOMOBILE from Earliest Days

Complete in Six Volumes

....BY....

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:: AND ::

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Assisted by a Corps of Experts

NEW YORK . . . . THOMPSON & THOMAS . . . . CHICAGO

wire (technically called the lead) from the battery is connected, N is the negative terminal, and H is the high tension terminal, to which the heavily-insulated wire to the spark plug is attached.

Thus, to trace the condenser circuit, the current from the battery originally passes from P to F, thence through the platinum points O and O1 to E, through the coil B B B, and back again to the battery through N. In doing this, two things happen: First, the central soft iron core A becomes magnetized, and second, an induced current is caused to flow in the secondary coil C C C.

The magnetization of the core A, however, causes the iron head D on the trembler blade D1 to be attracted to A, and thus break the primary current. Directly, however, this current is broken, the field about the coil B, which, in spreading caused the induced current in coil C, almost instantaneously collapses. In doing so, it causes a second and stronger and induced current to flow in C, but in the opposite direction, and further, induces a current in the coil B, also in the opposite direction to the former current in the battery.

The condenser is connected as a shunt (see Shunt) across the ends of the primary circuit, by its separate sets of leaves being attached at E and F. When the primary current is broken and an induced current is suddenly set up, the condenser takes this induced current, which is discharged into the condenser (like a Leyden jar), which then contains a "static charge." When the points O, O1 come into contact, this charge is discharged again, and assists the remagnetization of the core.

Figures 2 and 3 show an actual French coil in sectional plan and elevation, and after the above description, it will be sufficient to enumerate the various constructional parts.

A is the central soft iron core, made of many straight lengths of iron wire, and bound together by the insulating tube J. I is the primary coil, consisting of turns of insulated wire of about 16-gauge, wound in several layers, each layer being separated from the next by an interposed sheet of pa-

per soaked in paraffin wax. This primary coil is cased in a second ebonite tube J, and the secondary coil 2 surrounds it. This coil is constituted in the same way as the first, but involves many thousand turns of very fine wire, 36, 38, or 40 gauge, having double silk wound insulation. More care is taken also in insulating each layer from the next.

The composite coil is placed in one compartment of a rectangular box, and the condenser H in a second, the cover being formed by an insulatory plate J. G is the fixed end of the trembler blade, of which B is the soft iron head. The

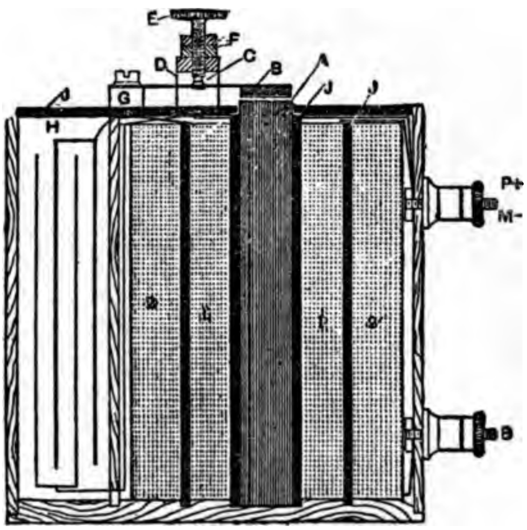


Fig. 2.—Section of French Coil in Elevation.

contact points are indicated by C, and the bridge D carries the trembler adjustment screw E, and the lock nuts F, F.

The condenser H is connected between the pillar at G and the bridge D inside the casing.

There are three terminals P, M, B to the case illustrated, indicating positive, P; negative, M; plug, B. The initials are those of the French words "pile," battery; "masse," earth, and "bougie," plug, respectively, and are the letters commonly found on French coils. In the elevation, P and M fall

one behind the other, and only one is capable of being shown. P is connected to the bridge D inside the casing, one end of the primary coil goes to M, and the other to G. The high tension coil has one end attached to B, and the other to M. These connections can be plainly seen in the plan, but are somewhat difficult to trace in the elevation.

The terminal P is always connected with the battery lead, and B with the sparking plug, but the terminal M is connected with some metallic part of the frame which acts as a return path both for the low tension current to the battery, and for the high tension current from the plug.

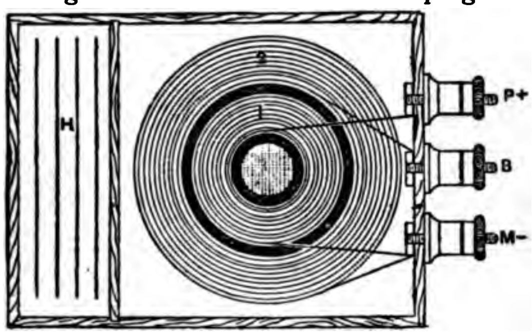


Fig. 3.—Section of French Coil in Plan.

Thus even supposing there to be four coils in one case, one end of each of the primary coils would go to a single terminal, and one end of each of the high tension coils would go to the same terminal, so that a single "lead" from this central binding screw would do all the "earthing" required.

Coils are sometimes made in divided sections but this type is not so common on automobiles.

Coil Clutch—See under Clutch.

Coil, Idle—A coil in which under certain conditions there is no induced current.

Coil Intensity—The strength of the current induced in a coil expressed in amperes, or, popularly, its electromotive force.

Coil, Quadruple—A multiple coil for use with a four-cylinder motor.

Coil or Magneto Wet—See Missing Explosions.

Coil, Resistance—See Resistance Coil.

Coil, Ruhmkorff—See Coil above.

Coil, Trembler—See Trembler.

Coil Trouble—See General Troubles with Coils, under Ignition.

Coir—A material made from cocoanut husk fiber, used for matting, cordage, etc. It rots in fresh water and becomes brittle under the action of frost.

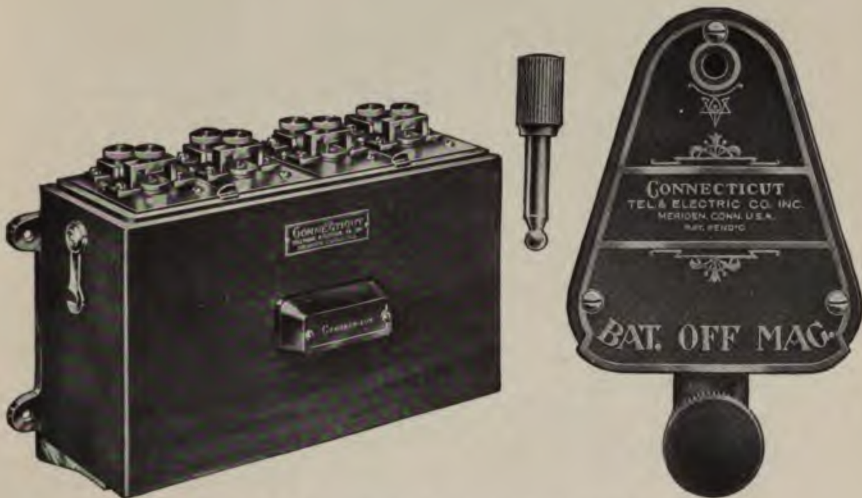
Coke—The solid product of mineral coal after the bitumen, sulphur and other volatile parts have been separated. It is used instead of coal where intense heat without smoke is required. Also used in electrical manufacturing, for arclight pencils, battery plates, etc.

Cold Chisel—See Tools.

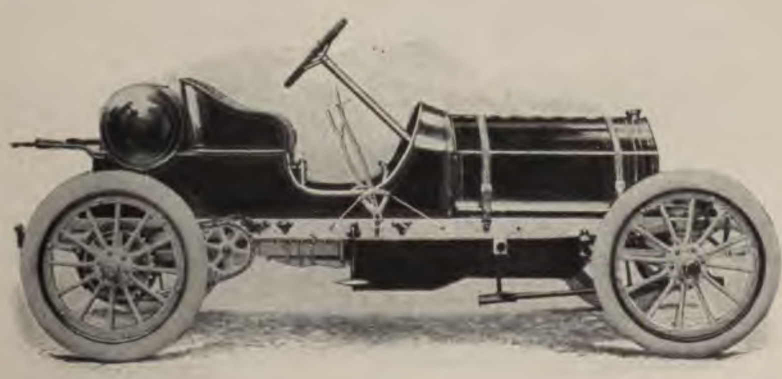
Cold Motor—See under Missing Explosions.

Cold Weather—In cold weather every precaution must be taken against the risk of the water freezing in the radiator or water jackets, as it may lead to burst pipes, or still worse, to a split jacket. To provide against this danger the water should be let run off every night, and in fact even for a prolonged stoppage during heavy frost.

In letting off the water in a typical machine the cap of the filling pipe should be unscrewed. The pipe leading from the water jacket should be opened, and also the cock of the pipe leading from the radiator to tank. If there is a cock to the radiator, this should also be left open to insure the last drop of water draining away. It is not sufficient to open a cock somewhere in the circulating system without making quite sure that the cock in question is at the lowest point, for very often cocks are fitted merely for testing the circulation, or washing-out purposes, and are not in the right position to entirely drain the system. It is sometimes impossible to completely drain the pump, so in frosty weather it may be well before starting to gently heat the metal casing by pouring hot



Coil and Coil Switch Used on Knox Cars.



The Apperson "Jack Rabbit."

water, in order to get rid of any ice that might interfere with its proper working.

Cold weather has a very great effect on the vaporization of gasolene, especially where it is accompanied by much moisture in the air. The formation of gas from a liquid necessitates heat, which is robbed by the gasolene from the air with which it mixes in the carbureter, and if this air is already at a low temperature, the vaporization is retarded, and any moisture entering with the air is frozen at the jet, thus choking it. To prevent this occurring, it is necessary to heat the air before it enters the carbureter, or to warm the carbureter itself by means of the exhaust gases. When this extra heat is required, it can easily be told by the appearance of the carbureter after the engine has been working a short time, as, if too cold, it will acquire a coating of white hoar frost. Means should be provided for regulating the amount of hot air, as too much heat is as bad as too little.

In cold weather it is essential that every preparation should be made as regards clothing. See Clothing.

Starting the Engine in Cold Weather.

Some engines are very difficult to start in cold weather, or when they have stood for some considerable time. Raising and depressing the needle valve of the float chamber rather briskly two or three times sometimes has the desired effect, when the starting-handle is rotated and the switch is on. If this fails, then a small amount of gasolene injected by a syringe or can into the cylinders through the compression cocks will both thin the lubricating oil and ease the piston rings, and also vaporize in the cylinders and fire easily when the attempt is made to start up. If no compression cocks are fitted, a small hole might be made in the inlet pipe as close to the engine as possible, and the gasolene squirted in there. The holes can be covered over if required by means of a spring clip similar to those in use on bicycle pedal centers for covering over the lubricating holes.

Collar—A boss formed on a shaft to prevent end motion.

It may be solid with the shaft, or a separate piece fitted to the shaft with keys or set-screws. See Bearings.

Also applied to an enlarged portion of the end of a car-axle to prevent the end-thrust of the journal bearing.

Collar-bearing—See under Bearings.

Collar, Compensating—An adjustable collar or boss fitted on a shaft and designed to counteract the effects of wear.

Collar, Pinch—A form of clamp for compressing a rubber pipe to regulate or stop the flow of a liquid through it; sometimes used in water circulation systems.

Collar, Thrust—The collar on a bearing which receives and transmits the thrust of a propeller.

Combustion—The state or operation of burning; the continuous combination of an inflammable substance with certain elements, as oxygen, chlorine, etc., generating heat or both light and heat. Chemically considered, combustion is a process of oxidation, uniting the oxygen of the air with any substance that is capable of oxidation, or in other words is combustible. It results in the formation of oxygen compounds, gaseous or otherwise, and the liberation of energy. In the gasolene engine combustion applies to the rapid oxidation of the mixture when ignited by the spark in the combustion chamber.

Combustion Chamber—See Combustion.

This is also called the cylinder "head." The valves open into it; the ignition spark occurs within it; and, unless the casting should happen to crack from a flaw or from neglect in frosty weather, the only concern it can give to the motorist is by getting hot or loaded with soot.

The causes for this part getting hot are:

1. The compression of the gaseous mixture takes place there; the work of compression heats the gas very greatly and much of this heat is given up to the metal inclosure of the compressed gas, namely, the cylinder head.

2. When the gas is ignited it reaches its highest temperature in the head, namely about 2,000° F. during the short time

that elapses before the piston moves forward, that is, before this heat is turned into energy. Naturally the walls in contact with this white hot gas get heated.

3. The hot exhaust gases pass out with considerable friction against the sides of the exhaust valve and its seat, thus doing work on and heating the cylinder head. A leakage past the exhaust valve during explosion will in the same way give rise to a hot cylinder head.

4. The uncooled exhaust pipe is usually in metallic contact with the head, and by conduction yields heat to it.

5. The head is in conducting connection with the cylinder which is being rapidly rubbed by the piston and rings. If therefore the piston lubrication is defective much heat is generated, and the head by conduction shares in the general resulting rise of temperature.

6. As every cycle of the engine adds its quota of heat to the head, a serious rise of temperature can only be kept down by conducting the heat away through the iron walls; this conduction will be impeded—

(a) If through excessive lubrication the inside of the combustion chamber is lined with hard caked soot.

(b) If the iron walls are too thick.

(c) If the outsides of the iron walls are not in sufficient contact with a cool body, that is, cool air or water. Therefore, on gilled cylinders clean away all mud from the gills, and in water-cooled keep the tanks full and the water circulation active.

7. An engine having a bad fuel efficiency from any cause, notably a low compression, pressure heats, late ignition or too rich a mixture, has a heating effect for a similar reason.

8. As a matter of engine design which does not concern the user, who has bought his engine and cannot alter the case, the amount of heat taken by the cylinder head under paragraphs 1 and 2 above will be less for any predetermined degree of compression in proportion as the amount of wall surface of the combustion chamber is small and the rate of compression and expansion rapid. Therefore, since a sphere

is the volume of minimum surface the combustion space should be spherical and perfectly smooth. This would mean a hemispherical piston, which is impracticable since the piston has no easy means by intimate contact with a cool body to dissipate its share of heat. The usual practice is therefore to make the area of piston surface a minimum, that is, a plane surface, and the best shape of the combustion space would then be a hemisphere.

9. If the muffler becomes sooted up or choked with splash mud, the non-escape of the exhaust will cause the head to heat.

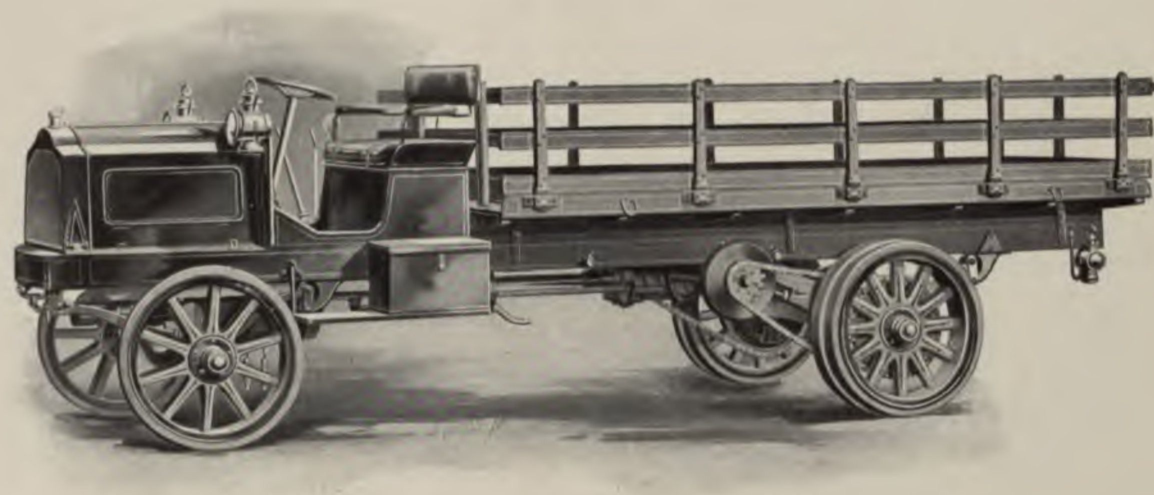
To avoid heating under paragraph 3, see that the valves are well ground in, that they open fully with great speed and give access to a good large exhaust pipe.

To avoid 4, introduce a good stout insulation of asbestos card between the exhaust pipe and the engine. This prevents the heat of the pipe from being transferred by conduction to the combustion chamber. The exhaust valve will receive advantage from every precaution of this sort, as the stem will keep cooler and will not tend to scale. It will fit its guide better. Whether the motor be water-cooled or not, there is no great objection to the exhaust pipe getting very hot, save that it indicates an inefficient engine, provided there is a solid economy thereby gained in the amount of cooling water and in cooling apparatus generally. See Cooling and Circulation.

The cylinder head should be smooth internally, and kept as free as possible from soot or hard deposit, such as is induced by over-lubrication, by the use of kerosene in excess, or by the persistent use of an ill-adjusted mixture where the amount of gasolene is in excess.

The volume of the cylinder head or combustion chamber is generally about one-sixth to one-fifth of the cylinder volume.

Combustion, Spontaneous—The ignition of a substance by the heat generated in its oxidation, which must be of an exceedingly rapid character to cause this phenomenon. It most



The Packard 3-Ton Truck.

frequently occurs in heaps of oily rags, piles of wet coal, etc. Oily cotton waste should therefore not be allowed to accumulate in dangerous places.

Commercial Cars—Motor vehicles are now largely used for commercial purposes, and their utility and value for the transportation of passengers and freight, the delivery of goods, etc., are no longer questioned. There are so many types of these cars in the market that the public has ceased to be surprised at the appearance of new models of commercial cars or at new methods of utilizing them. Cars are manufactured for trade purposes in all forms and sizes, and of carrying capacities from a few hundred pounds to five tons or more. Many manufacturers of automobiles more particularly designed for pleasure have turned their attention also to the building of commercial cars. The latter is now a very important part of the automobile industry, and its importance is ever on the increase. A number of varying types of motor cars in commercial use and public service are illustrated by photographs elsewhere in this work.

Advantages of Motor Trucks.

The claims that may reasonably be set forth for the commercial motor truck have been well stated as follows:

"It has many advantages over horse-drawn vehicles. It is more economical. It is rapid, which enables one truck and operator to do the work of several teams. It has a big advantage for delivering urgent orders, and customers will readily realize a merchant's superior service in this respect—enabling him to get goods to them quickly by the use of the auto-truck. This proves a big advantage.

"It will make long trips to distant places and depots a convenience and not a burden or worry. With an auto-truck these trips will not cut into the best part of a day as they do with a horse-drawn vehicle. It consumes fuel only while it is in motion—does not eat while it is idle or standing in the stable, as with horses, therefore the highest value is obtained for every cent of fuel cost—no waste.

"It will run every day, winter and summer, as many hours as you require, not needing to have days of rest between, as with horses. The auto-truck will perform its work as well in the last hour of the day as in the first, and it does not get tired.

"It will work equally as fast in summer as in the winter—no danger of overheated horses in hot weather and no risk of horses breaking legs on icy streets in winter, or delays in having shoes sharpened.

"It will not shy at anything, or run away, or bite, or kick—will stand without hitching.

"It can be stopped quicker and in much shorter space than a horse-drawn vehicle, which is important in an emergency to avoid collisions, etc. No risk of throwing horses and injuring them by sudden stops.

"With the use of auto-trucks the streets will be sanitary and clean, and will not wear out as fast as if traveled by horse-drawn vehicles exclusively.

"As it can be manipulated more readily and in less space than a horse-drawn vehicle the auto-truck facilitates traffic on congested streets.

"It requires less stable room, and eliminates the feed-loft entirely—not necessary to put in a big quantity of feed at certain periods of the year. No rats or vermin around the premises.

"It is safe from diseases common to horses, and will not die or require any attention during the night.

"It is the modern and progressive method of hauling, and in addition to other advantages is a good advertisement."

Commercial Cars in Public Service.

Many cities are adopting motor cars of the commercial type for fire and police service, and their success in such use is exemplified by the results of a test made by the Indianapolis department of public safety prior to purchasing several Rapid cars to be used regularly in the police patrol service. In two days, from August 17 to noon August 19, fifty-one runs were made. The average run—round trip—was twenty-nine blocks,

Protective Fire Car, Model G—Knox Automobile Co.—40 H. P., Speed 40 Miles an Hour.

A Knox Police Patrol Car.

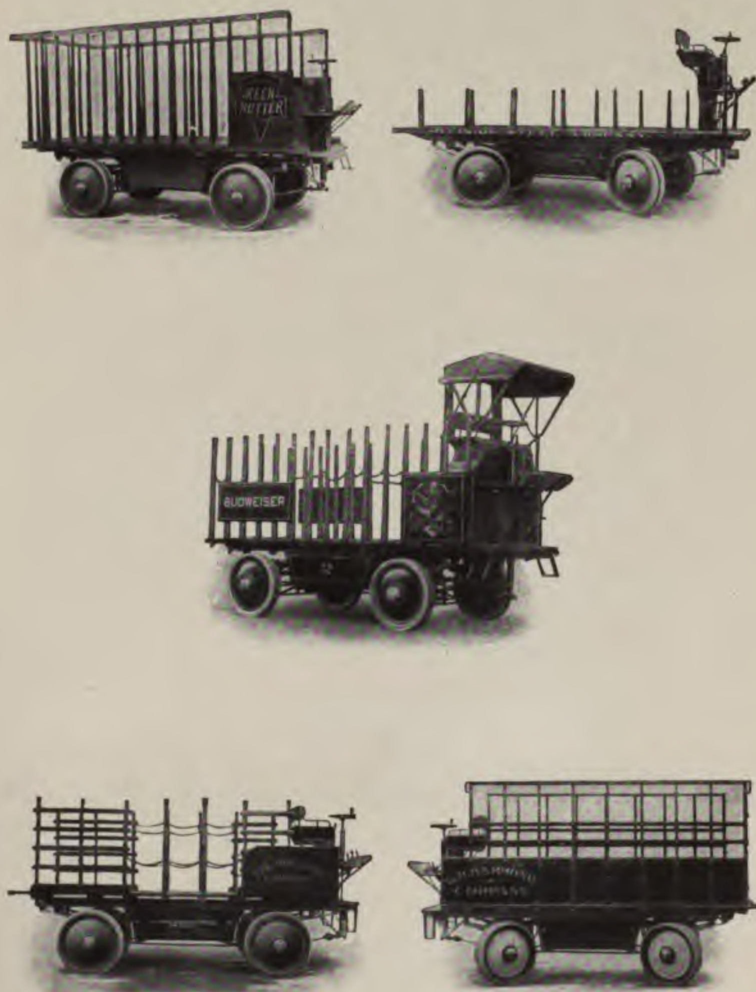
and the average time consumed in making the entire trip was 11.5 minutes. The time required to get under way after calls were received averaged eight seconds. It must be remembered that this time includes starting the dead engine, loading of prisoner—in some cases three of them—and telephoning to headquarters. Another feature of the car's performance was the economy of fuel consumption. A total of 185 miles was covered on 12 gallons of gasolene, or 15½ miles to the gallon. This amounts to 14/37 cents per mile for fuel. The gasolene was personally measured by the officials, as they were particularly interested in the comparative cost between the motor and the horse. As the car did the work of three patrol wagons, nine horses, three drivers and six patrolmen, the net saving amounts to several hundred dollars yearly.

Gasolene-Electric Cars.

"Mixte means mixed in the motor field in France and Germany, the particular application being a mixing of gasolene and electricity in the propelling of a motor car. In America we have the mixte car, but prefer calling it the gasolene-electric, which could be abbreviated to "gasolect," formed from the two words gasolene and electricity. The pioneer builder of such cars in America was the Electric Vehicle Co., which built and demonstrated in 1907 a pleasure car operating on this principle. In these cars the gasolene engine is in place and in the rear of it and coupled direct to its crankshaft is an electric generator that furnishes electricity, which is in turn delivered to electric motors that drive the rear wheels of the car. The system comprises three essentials: the gasolene motor as a prime mover, the electric generator that makes the electricity, and the electric motors that propel the wheels. In some gasolene-electric systems a fourth essential is used in the form of a large storage battery, into which the excess electricity, not used by the electric motors, is discharged, and from which it can be drawn when an overload pull is required. The battery is not a favorable essential with many makers because batteries are variable quantities on heavy trucks; they

are heavy and often short lived. Of late not a few makers have experimented with a kind of automatic control between the electric generator and the electric motors, so there is a balance existing between them whereby there is no surplus current produced by the generator, and yet enough power for any overload that is met with.

"One of the latest of these automatic controls is known as the Markle system, in which the inventor, John H. Markle of Chicago, uses but three essentials, gasolene engine, electric generator and electric motors on the back road wheels. To demonstrate the ability of the Markle system it has been installed in a large 5-ton electric truck used by Armour & Co., Chicago. The original electric truck had an underslung battery and a double motor system, one motor geared to each rear wheel. In installing the Markle electric system the battery with its carrying platform was taken out and a dropped subframe substituted, this subframe extending practically from the front to the back axle and about as low as the axle. On this subframe are carried the gasolene motor in front and the generator in the rear of it, the latter coupled direct to the rear end of the gasolene engine crankshaft. The two electric motors used on the rear wheels were not altered in the least. The electric wires from the generator were run to the controller under the seat with connection to a starting rheostat on the side of the vehicle cover at the left end of the seat, as well as to a voltmeter above the rheostat. This comprised the sum total of the changes. The running gear, steering mechanisms and other parts were not molested. With the new system as used on the Markle the control is confined to controlling the speed of the gasolene engine by the throttle and spark, although Mr. Markle states a governor will be placed on it and thereafter the driver's attentions will be limited to the controller handle in the left of the seat, the starting rheostat and steering the machine. The driver is cautioned to keep the voltmeter showing approximately a voltage of 110, although when quickening speed or taking heavy grades it often is necessary to let it go higher and at times a maximum



"Couple-Gear" Electric Power Trucks (Motors Contained in the Wheels.)

of 150 volts is reached. On grades the driver also speeds the gasolene engine, which with normal work operates at a crank-shaft speed of 600 revolutions per minute. The chief features of the Markle gasolect system lies in the construction of the electric generator, as well as the balancing between it and the electric motors whereby a battery is eliminated, yet sufficient power obtained for overload times."—Motor Age.

Since the above was written, in 1908, the gasolene-electric system has been still further developed for use on commercial cars.

"Couple-Gear" Trucks.

The "Couple-Gear" trucks which are illustrated by photographs are effective examples of modern commercial cars. They are electric and gasolene-electric or "gas-electric" vehicles. The transmission is called "couple-gear" because the principle is that of "couple-action." The power is applied at the rim of the wheel with a speed reduction of 25 to 1 and without the aid of countershafts, transmission losses thus being practically eliminated. The electric motor is contained in the wheels, the power being applied to both sides of the wheel by a single motor carrying two pinions, which pull up on one side of the wheel and down on the other side. The motor is fixed at a slight angle, which enables each pinion to engage its respective gear and run free of the other. The axle stubs on which the wheel turns are integral with the motor castings, which are brought together in such a manner as to insure perfect alignment of the bearings.

The principle involved is the same as that used in winding a watch with the thumb and finger, except that the motion is continuous. In mechanics the movement is called "couple-action" and it is a theoretically ideal transmission means.

The practical application of "couple-action" is made possible with the "Couple-Gear" from the fact that the motor is contained inside of the wheel or driven member, and is placed in such a manner that the pinions on both ends of the motor shaft are permitted to drive from their opposite sides. An "evener"

or equalizing device divides the force equally between the two pinions regardless of any unequal wear or adjustments.

Gas-Electric "Couple-Gear" Trucks—For service where convenient or economical charging facilities are not available, the manufacturers equip their standard machines with an explosive engine and generator in place of the "storage battery," this power-unit being the same as a stationary electric plant and having no connection to the moving parts of the truck except through the medium of the cable which conveys the current to the controller and thence to the motor-wheels. In the gas-electric truck they claim to have all the advantages of electric control with the added advantage of unlimited radius of travel and have eliminated some of the complications of the mechanically controlled gasolene truck, such as change-speed gears, reverse gears, countershafts, sprockets and driving chains, or the alternative, friction-drive devices.

The gasolene engine in the gas-electric truck is governor controlled, the tension of the governor spring being regulated by the operator's hand lever to suit the various road conditions. The current is generated no faster than demanded by the driving motors and there is no current flowing when the vehicle is coasting or at rest.

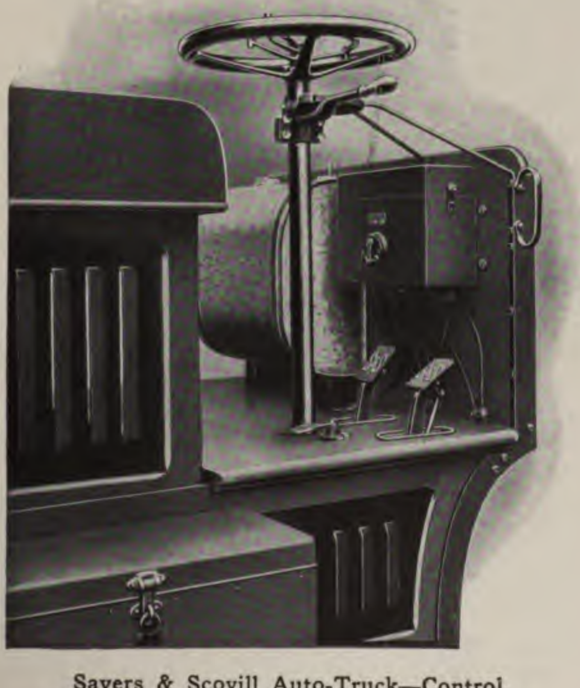
The "Couple Gear" trucks are made with front-wheel drive and front wheel steer, and also with four-wheel drive and four wheel steer.

Sayers & Scovill Auto-Trucks.

The commercial auto-trucks bearing the name of Sayers & Scovill are operated by means of air-cooled 4-cylinder gasolene engines. The transmission consists of sliding gears, standard improved design, three speeds forward and one reverse, with direct drive on high gear to differential. The gears are of large diameter and wide face, flange bolted to shafts and made of the highest grade nickel steel ground to a standard after hardening. Timken roller bearings are used throughout the transmission.

The differential is integral with the transmission and has

Sayers & Scovill Auto-Truck—Clutch.



Sayers & Scovill Auto-Truck—Control.

bevel gears inclosed in a steel housing. These bevel gears have a square hole to reeeive the squared end of the jack shaft.

The transmission is built for heavy continuous service, well proportioned and compact. The transmission case is made of best aluminum alloy, well ribbed and reinforced, and oil tight. The jack shaft revolves on large annular ball bearings enclosed in a steel casting which is directly connected with the radius rod, thereby putting no strain on the frame.

The clutch and control are illustrated by photographs. The clutch is of the internal expansion type, 15-inch diameter, faced with leather reinforced with 200 hickory pegs, and revolves on a roller bearing.

The steering gear is irreversible, with 16-inch hand-wheel, operated by worm and nut. The small self-finding gear shift lever is situated under the hand-wheel, thus enabling the operator to shift the gear without changing his natural vertical position. Two pedals are used. The outer pedal first disengages the clutch and then applies the emergency brake; the inner pedal applies the light running brakes. The spark and throttle levers are situated in the center of the hand wheel, the segment always remaining stationary.

Commutator—This term is frequently erroneously applied to describe the appliance which automatically makes contact and so closes the low tension circuit. So called after the commutator of a dynamo, which commutes or changes the direction of the flow of current. The term, although in general use, is really a misnomer, as the flow of the current is not changed in direction, but only interrupted. We should use the term Contact Maker to describe this contrivance and Contact Breaker in the case of the break arrangement used for magneto ignition. See Contact Maker.

See Principle of the Motor, under Electric Motor.

An illustration on another page shows the Lacoste commutator, which is fitted with the Lacoste patented insulator terminals made in America under license of the French patentees. With these terminals, it is claimed, the wire is firmly held

and cannot jar loose; no stripped portion of the wire is exposed, and dirt and moisture cannot cause trouble.

Commutator Chain Drive, Adjusting—See under Ignition.

Commutator, Ignition—In an ignition system a contrivance for varying the strength of the electric current or for regulating its direction, through the external circuit. See Commutator above and Ignition.

Commutator Troubles—See under Lubrication.

Compensating Brake—See under Brakes.

Compensating Gear—Another name for the balance gear, as it compensates for the difference in speed of the outer and inner wheels when the vehicle is turning a corner. See Balance Gear; Differential.

Component—A constituent part of anything. In mechanics one of the parts of a strain, acceleration, velocity, etc., from which the whole may be compounded by geometrical addition. The real component of a force is such a component as is itself a real force.

Compound Engine—An engine which utilizes the exhaust steam in a low-pressure cylinder or cylinders where it does work by expansion.

Compression—The maximum degree of pressure measured in pounds per square inch exerted on the volume of gas between the piston and the combustion head at the point of the piston's farthest travel on what is termed the compression stroke. The efficiency of the expansion depends to a large extent on the compression being as nearly perfect as possible.

Good compression means that the entire pressure of the piston on the compression stroke is utilized in compressing the volume of the charge, and that no escape takes place at the valve joints or piston rings or elsewhere. Such escape will affect the power of the engine. To insure the highest efficiency, the compression must be quite perfect at the moment of firing the gas. According to the degree of leakage, so the power of the impulse stroke will be affected. At the same time, too high a compression, if other factors in the en-

gine's design be not in accord, may result in undue hammering at the bearings and be accompanied by premature firing. See Bad Compression, under Repairs and Adjustments.

The resistance which one experiences in turning round the starting handle of a gasolene engine is a rough measure of the compression. An engine developing 6 H.P. per cylinder should require a strong muscular effort to pull the piston up over the compression.

As a good compression is almost an unmixed benefit, care should be taken to maintain it by attending to the following points:

1. Engine cylinder lubrication.

2. Maintaining a perfect surface on the valve edges and their seats.

3. If there be a joint between the cylinder head and cylinder, keep that perfectly gas tight.

4. See that there are no leakages of gas past the spark plug, petcock, or inspection plugs in the cylinder.

5. See that the piston rings are a perfect fit. Only examine for this after a long period of use of car, say 10,000 miles.

To test for leaks, squirt a little kerosene or lubricating oil round the joints, between spark plug and cylinder. Then get some one to turn the crank against compression and watch for bubbles. Do the same to the joint of the head to the cylinder, if any.

If these are all right, but the compression leaky, clean the valves. If this does not cure the defect, grind the valves in with fine emery and kerosene or gasolene. When they are a perfect fit, if there is still a leak, it is past the piston rings.

Small pressure gauges which can be screwed into the place of the spark plugs are sold to enable the state of compression to be easily measured.

The ordinary compression pressure in motor car engines is about 80 pounds to the square inch, but for engines which are intended to run particularly slow, so that the car can be driven as far as possible without changing gear, lower compressions down to 60 pounds to the square inch are used.

When fuel economy is being carefully studied, however, much higher compressions are used, namely, up to 100 pounds to the square inch. Such pressures are used, for example, in "economy races."

The compression pressure thus spoken of is not, however, a constant pressure which always occurs in the engine under all conditions of its normal use, for obviously when the throttle on the inlet is partly closed the amount of entering gas is diminished and the pressure is diminished. Again, even with the throttle on the inlet fully open, if the engine is running excessively fast, the full charge of gas has not time to enter the cylinder, and here again the pressure is diminished.

Now the efficiency of an engine in regard to fuel consumption per "brake-horsepower-hour" is always less when the compression is less, so that if an engine is run below its normal speed by throttling the inlet, or above its normal speed, it is less efficient in fuel per horse power hour.

The compression is also affected by a number of less obvious considerations. Important among these is the amount of heat which the incoming cool charge of gas receives from the undischarged residue of the exhaust, and from the hot piston and cylinder walls. In the case where the governing of the engine is effected by throttling the exhaust, and not the inlet, the amount of extra heat so received may be very important. The extra heat expands the gas inclosed in the cylinder and increases the compression, and also the fuel efficiency.

Again, as is well known, the act of compressing a gas heats it, and this heat would increase the compression pressure to an enormous extent if it were not for the fact that a great deal of this valuable heat is wasted by being conducted away by the walls of the cylinder. The quicker the engine rotates the less time there is for this loss to take place.

In order to secure as little loss as possible, the combustion chamber should be made with the minimum of inside surface area.

Compression Defined.

"Bad compression" is the verdict frequently given by the repairer to whom a car is taken for examination when a loss of power has been noticed in the running of the vehicle. The query has often been put, "What is bad compression?" but the explanation has not always been quite satisfactory to the querist. To really understand compression, it is necessary for the motorist to be thoroughly conversant with the Otto cycle principle upon which the motor works. Briefly, compression arises from the drawing into the cylinder of a charge of gaseous mixture by one stroke of the piston in its downward direction, and then with the next, or upward stroke, compressing the gases into a space of approximately one-fourth of the cylinder's cubic capacity, ready for their ignition and expulsion during the two succeeding strokes of the piston. The compression or squeezing together of the gases naturally gives them greater rebounding, expansive or explosive properties when they are ignited by the electric spark. In this way, the power of the stroke of the engine is produced. It follows, therefore, that the power developed by the engine depends very largely upon the extent to which the gases taken into the cylinder are compressed, that is, upon compression, though this is also a question of the number of revolutions which the crankshaft makes per minute. The limits to which compression can be carried are restricted, however, as above a certain critical pressure self-ignition of the charge occurs, with all its attendant objections.

Loss of Compression—Causes.

One of the principal causes of the loss of compression is a bad seating of the inlet or the exhaust valve. The latter gives more trouble, as a rule, than the former, it having more work to do and moreover having to withstand the great heat to which it is subjected by the outrushing exhaust gases at the end of each power stroke. It should be the invariable rule to examine the valves first. The inlet valve in many engines has to be first removed before the operator can reach

the exhaust valve. This gives an opportunity of first examining the inlet valve before passing on to the exhaust valve. In no case should an examination of the latter valve be overlooked if the former is not found to be perfect. Such scamping of the work will only result in further dismemberment of the valve mechanism.

The signs of a worn valve are dark patches or pitting on the conical face of the valve or its seat. In many cases, it will be found that the valve itself will be pitted and marked much more than the seat; the one being good and the other only showing slight signs of imperfection should not be allowed to pass.

Still dealing with causes, where the head of the cylinder is in a separate casting to the cylinder itself, the joint should be carefully examined if the valves are found to be in perfect order. Even should they not be quite perfect, if the compression is very bad it would be as well to look to these joints, particularly if they are made by the aid of a copper and asbestos washer. Where a ground conical joint is used, there is hardly any fear of a leakage at this point, and it is not advisable to disturb this joint unless one has very excellent grounds for believing a leakage to be occurring.

The next point at which compression is likely to be lost is the imperfect fitting of the piston and its rings in the cylinder. The ideal conditions for a piston working in a cylinder would be a perfect fit between the piston and the cylinder, but as the question of heat has to be considered, it is not possible to attain this ideal fit, for if the piston were too tight, the heat generated by its frictional contact would be so intense as altogether to prevent its working. As it is, the difference in measurement between the piston and the cylinder walls does not amount approximately to more than one-hundredth part of an inch. There is this difference to be provided for, however, and although the hundredth part of an inch may seem a small matter, yet it allows of the escape of a very appreciable quantity of the explosive gases from the cylinder before the charge is fired, and is of vital importance

in the construction of an engine such as that employed in driving a motor vehicle. The piston, then, having of necessity to be smaller in diameter than the cylinder, it becomes necessary to make a gas-tight joint by the aid of piston rings. For this purpose, three or more rectangular grooves are cut in the upper end of the piston, and into each of these grooves is sprung a cast-iron ring so constructed (being severed at one point) as to have in itself a certain amount of spring which keeps it in constant contact with the walls of the cylinder, and so forms the necessary joint. In course of time, these rings will wear to such an extent as to permit a portion of the compressed charge to escape, and, what is more destructive, portions of the ignited gas also escape by them, thus tending to their rapid destruction when once they begin to give way. It is invariably the top piston ring which gives way first, as this does the bulk of the work in preventing the passing of any part of the compressed or exploded charge. The first ring having failed, the remaining ones go in succession, so that the loss of compression is on this account spread over a fairly long period of time. If all the rings went simultaneously, then the loss in compression would be so sudden that one could turn to the engine and immediately go to the piston rings as the cause of the trouble; but as these go successively, the power diminishes very gradually, and it is not until the rings are really bad that one turns to these.

How to Test Compression.

The testing of the compression is a somewhat difficult operation to obtain satisfactory results, as so many elements enter into the conditions. These we will touch on after describing how compression may be tested. The piston should be freed in the cylinder by injecting a small quantity of gasolene or kerosene. The starting handle should be put into engagement, and should be revolved until resistance is felt on one upward stroke only. It is by the amount of resistance which is felt on the starting handle that the amount of compression in the engine may be judged. In order to obtain a

correct idea of the amount of compression there is in the cylinder, a slow steady pull should be given to the starting handle—not a sharp, quick jerk, such as is necessary in the starting operation. In order to free the valves and to get the engine as nearly as possible into its free working condition, two or three sharp revolutions by means of the starting handle may be given to the engine, after which the compression stroke should be felt, and then a long steady pull on the handle taken, from which to judge the amount of compression. In doing this, the operator can steady himself by placing the left hand on the front part of the dumb iron, while with the right hand he grasps the starting handle. The amount of compression in the cylinder is judged by the length of time occupied in overcoming the resistance. Incidentally, the power of the operator is a factor which also enters into one's judgment. For a two, three or four-cylinder engine, it is necessary that each cylinder should be tested independently.

Another method of testing is to remove the sparking plugs. This may possibly in many instances be a more simple operation than that previously described. Many conditions enter into the judgment of the amount of compression, as usually tested, so that one might easily misjudge the length of time which elapses between the compression being felt and its release by depending merely on the physical strength of the operator. The latter is a very essential point. What to a moderately muscled man may seem a high compression would to an athlete in training be a mere nothing. So that, altogether, the testing of compression by these methods is at best very unsatisfactory.

Correct Testing.

A more satisfactory method of ascertaining the correct compression in the cylinder is to have an adapter made to fit into the sparking plug orifice, this attachment carrying a small pressure gauge such as is used for tire inflation, the dial of which is marked up to 100 lbs. per square inch. This should be sufficiently high for any engine. The gauge itself

should be screwed into the adapter, so that the extra amount of compression space obtained by the use of the device may be as small as possible. It only now remains for the gauge to be screwed into the cylinder, and then for the operator to watch the highest point to which the index registers, in order to obtain the exact amount of compression of the particular cylinder under test. This figure, of course, will not correctly indicate the amount of compression which will be present when the engine is actually working. In this case, it will be higher than that indicated.

Incidentally, it may be mentioned that suction may also be tested in a similar manner by the fitting of a gauge, the dial of which is marked below zero, and not above as with the compression indicator.

No hard and fast line can be given as to the amount of compression which should be registered, for this varies with many engines according to the speed at which they run, and the diameters of their flywheels to a certain extent. The average compression, however, is about 75 lbs. to the square inch.

The most satisfactory and practical way of finding out the condition of one's engine is to test the compression when the engine is in good going order, and to make a record of the compression and suction (if tested), and to use these as standards of comparison when the engine is out of order and needs attention in the manner already indicated. Measures must then be taken to restore the engine to its normal condition of working.

Faulty Joints and Piston Rings.

In the case of a loss of compression through a bad joint, the remedy is obviously to replace the faulty joint with a new one. New joints can always be obtained from any good local repair man or accessories dealer. Piston rings occasionally cause a loss of compression by turning round in their grooves until the slots are in line. This can be prevented by screwing a stud into the piston between the ends of each ring. This arrangement does not in any way affect the action of

the rings. As to the fitting of piston rings, this is, generally speaking, an operation which is best left in the hands of a competent repair man, though the necessary instructions for the fitting of piston rings are given elsewhere in this work. See Overhauling.

A Cracked Piston Crown.

The turning of piston rings so that cuts are in line may account for loss of compression, and if this be the case, cylinder or cylinder head must come off in order that the rings may be turned so as to break joint with each other. Should attention be given to all the points enumerated above, and the loss of compression continue, it would be well to do as did a western motorist who suffered in this wise. He scraped the carbon deposit off the top of his piston and found that the crown thereof was cracked.

Compression Relief Devices.

A neat little adjunct made and fitted to his motor by an enthusiastic amateur is described below.

Having had some trouble through loss of compression by the usual compression relief tap, he designed the fitting illustrated in Fig. 1. The body A may be of steel or gunmetal, and is made to screw into the cylinder head by the screwed boss D. A small hole is drilled through this and coned to form a valve seating for the needle valve B. This is threaded, as shown, so that the valve may be screwed down hard and form a perfectly gas-tight joint. A hole is drilled at C for the gas to escape through when the valve is unscrewed to release the compression. The valve B having a coarse pitch screw thread, it is only necessary to give the handle a half-turn to obtain sufficient compression release space. Another feature of the device is the recessed top of the body, as indicated by the dotted lines, by means of which kerosene or gasolene may be run into the cylinder by removing the valve B and stopping up the relief hole C.

Referring to this device another motorist suggested an im-

provement by cutting a slot down the side of the screw valve B, making this the vent in place of the hole C. To carry out this idea would necessitate the fitting being made much larger, as the diameter of the screw would have to be enlarged considerably to leave it sufficient strength after the slot had been cut. Many motorists in recent years have had this or a similar device fitted to their engines.

Fig. 2 shows a useful little fitting employed in conjunction with compression relief cocks. It is a well-known fact that a compression cock, to be of any use, should have a fairly large hole in it. On the other hand, if such a cock were used on

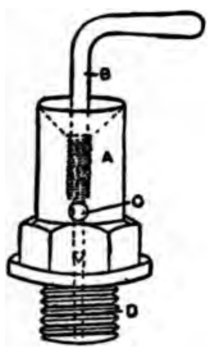


Fig. 1

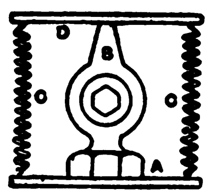


Fig. 2

the suction stroke, pure air would be drawn into the cylinder in such quantities as to weaken the mixture and cause it to be non-explosive. To overcome this difficulty, a motorist devised the fitting depicted in Fig. 2. A washer or plate A is made to fit over the screwed end of the relief cock B, on to which two spiral springs C C are fastened by convenient hooks. Across the mouth of the relief is another plate D, also connected to the springs. It will be seen that when the cock is opened, compression is relieved by the lifting of the plate away from the opening of the cock; but on the suction stroke the plate closes the orifice, preventing pure air being drawn in, a perfect combustible mixture being obtained therefore, in conjunction with the relief cock, which really does release the

compression to an appreciable extent in high compression motors. This fitting would be of more practical use to motor cyclists than to the automobilist, although to the latter it is not without its value, particularly in the case of the single-cylinder engine.

Compression Igniter—See under Ignition.

Compression, Loss of—See under Loss of Power.

Compression Relief Devices—See under Compression above.

Compression Space—The space occupied by the charge in a cylinder at the end of the compression stroke.

Compression Stroke—The particular movement of the piston which compresses the explosive charge. See Internal Combustion Engine.

Compression Stroke—See under Pounding and Knocking.

Compression Tap or Cock—A small cock at the top of cylinder by opening which a portion of the charge can escape instead of being compressed. It is now mainly useful for locating the position of the piston when checking the timing, and for injecting kerosene or gasolene. With the latter object in view a cup is sometimes formed on the top. Also called Relief Cock.

Compression Valve—See Valves.

Condensation—The act of making dense or compact. In physics the act or process of reducing a vapor or gas to a denser form, as steam to water or a liquid to a solid or semi-solid. In chemistry the rearrangement of atoms so as to form a molecule of greater density and weight.

Surface condensation is a method of condensing steam by contact with cold metallic surfaces instead of by the injection of cold water, etc.

Initial condensation is the condensation that occurs when steam first enters a cylinder, the temperature of which is lower than that of the steam.

Condensation in electricity is applied to the concentration of electromotive force by the effect of induction between conductors.

Condenser—An apparatus for converting the exhaust steam from a steam engine into water for further use in the boiler, and to prevent an emission of steam.

In electrical phraseology an apparatus used in connection with an induction coil. See under Coil.

The electrical condenser usually consists of two conducting surfaces separated by a non-conductor. A practical form of condenser is seen in the Leyden jar.

The condenser of an electric coil (see Coil) consists of a number of superimposed layers of tinfoil separated from each other by thin sheets of mica or paraffined paper. Alternate layers are electrically connected, so that the finished condenser practically consists of two large sheets of tinfoil separated by thin sheets of insulating material. The wires from the condensers are connected so that were the condenser a conductor there would be a path for the primary current through it, even when the platinum contacts were apart.

A condenser possesses the quality of being at the same time a non-conductor and yet of being able to be charged with electricity, and the object of using it in a coil is to prevent the destructive spark which would occur at the platinum contacts were there no other way of getting rid of the high electromotive force generated on breaking the circuit at those points. This high electromotive force may be said colloquially to spend itself in charging the condenser, and the spark at the contacts is much lessened in consequence. Another effect, indirectly due to the condenser, is to increase the brilliancy of the spark at the sparking plug. This is owing to the fact that the primary circuit of the coil is broken more suddenly when a condenser is used, since the energy stored by the self-induction of the coil is used to charge the condenser, instead of being available to overcome the reluctance of the air gap between the platinum contacts.

The successful operation of a condenser depends upon its insulation being kept absolutely dry.

Condenser Perforated—See under Missing Explosions.

Conduct, General—See under Driving.

Conduct in Emergencies—See under Driving.

Conductance—In electricity, the capacity of any substance for conduction or transmission of a current.

Conducting Wire—See under Wire.

Conduction—Transmission of electricity from points of high potential to points of low potential, from particle to particle and a distance. Also applied to the similar transmission of heat, sound, etc.

Conductivity—The power of conducting heat, electricity, etc., the property of being conductive. Thus, metals have a high degree of conductivity for electricity. In any substance the conductivity for electricity is the reciprocal of the resistance.

Thermal conductivity, or the power of conducting heat, is in general much greater in solids than in liquids and greater in liquids than in gases. Both liquids and gases become heated by convection, not by conduction. See Convection.

Conductor—Any medium which affords a path for electricity. Most metals are good conductors, and amongst the best are silver and copper. Water also forms a conductor, and the fact should be borne in mind during wet weather, when short circuits frequently occur through defective insulation allowing water to come near the wires and thus take the current away on some other path.

A prime conductor is that part of an electrical apparatus which collects and retains the electricity.

In physics a body that conducts or transmits through its substance energy in any of its forms is called a conductor, and the use of the term is sometimes extended in mechanics to include a connecting-rod which transmits power in a machine.

Cone—A circular piece of hardened steel with a concave ther suitable surface to form a bearing or race for the of a ball bearing. Also part of a clutch, and sometimes r operating the internal brakes in epicyclic gears.

In modern geometry, a cone is described as any surface generated by the revolution of a line one point in which is fixed. In a right cone the base is a circle and the axis, or line passing through the vertex and the center of the base, is perpendicular to the plane of the base.

Cone Bearing—A bearing in which a cone-like end supports the revolving part.

Cone Clutch—See under Clutch.

Cone Pulley—A pulley wheel having a number of faces of varying diameter, over which a belt or belts may run to transmit power. It has been used in motor car construction as a means of varying the speed of the vehicle, but without much success. Also called Stepped Pulley.

Cone, Spraying—An attachment in some carbureters for the purpose of effecting more complete vaporization of the fuel.

Cone, Truncated—A cone whose vertex is cut off by a plane parallel to its base.

Conical Valve—See under Valves.

Connecting Plug—A small piece of metal fitted with a handle in the nature of a key, which is used to join two parts of an electric circuit together.

Connecting Rod—A general term applied to any rod which connects two moving parts and transmits motion from one to the other in the same plane. The more particular use, however, is to describe the rod which transmits the reciprocating movement of a piston or cross-head to the circular motion on the crank pin in engine construction, and which is also known as the Engine Connecting Rod. See Internal Combustion Engine.

Connecting Rod Bearings—See under Internal Combustion. **Engines.**

Connecting Rod End Slap—See under Pounding and Knocking.

Connections—See Electrical Connections.

Connections, Gear—See under Change Speed Gear.

Connections, Loose, Etc.—See under Ignition.

Connections, Making Electric—See under Ignition.

Connections, Water, Loose—See Miscellaneous Roadside Repairs.

Connections, Water System—See under Circulation.

A photographic illustration shows what is known as the "Eclair" instantaneous pump connection. This connection is described as universal, being adapted to any automobile tire, valve, or pump. It is attached to a tire valve by simply pressing it on and removed just as simply by pulling it off. The apparatus consists of a compression chamber hermetically closed by a rubber washer of special construction. The washer is held in place by a metal disk, which is screwed into a removable ring placed over the compression chamber, and is drawn up tightly against a flange by means of a metal disk. Every part of the connection is easily removable.

Many pump connections leak more or less, and the leak increases with the pressure. With the "Eclair" connection, it is claimed that as the pressure increases the air in the compression chamber expands the rubber washer and so augments its adhesion to the tire valve. It is attached to pump hose in the ordinary manner.

Constant—That which remains unchanged or invariable. In physics it is the numerical expression of any property of a body determined under uniform conditions, as the base of a cylinder, etc.

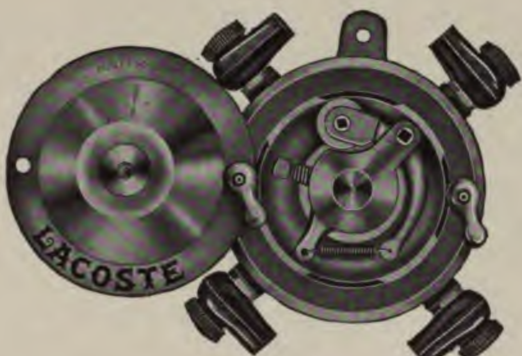
Constricting Brake—A band brake. See under Brakes.

Constricting Clutch—See under Clutch.

Contact—The relation of being in touch. In electricity, a piece of metal which assists in completing the circuit.

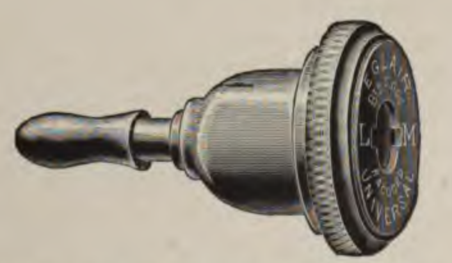
Contact resistance is the resistance due to the want of perfect union between two connecting surfaces in the circuit.

Contact Arm or Lever—Sometimes called the hammer. In low tension magneto ignition this is the lever which is operated on by the interrupter catch through the medium of the striker, and so breaks contact with the igniter. See Ignition.



The Lacoste Commutator—Lovell-McConnell Mfg. Co., Newark, N. J.

Lacoste Patent Insulated Terminals As Used in the Lacoste Commutators.



"Eclair" Instantaneous Pump Connection.

Contact Breaker—This term was introduced in connection with the original De Dion system of ignition, wherein the vibration of the trembler caused the sharp rupture in the low tension circuit necessary to cause the sharp rupture in the high tension circuit in the coil, which in that case was not fitted with a trembler. The term has since been used very loosely, and as the system above referred to, as well as the more general wipe system, is essentially a contact maker, we use Contact Maker to describe both, and adopt Contact Breaker here only in dealing with the arrangement for breaking contact when magneto ignition is referred to. If a special term is required to indicate the trembler blade type of contact maker the combination term "make-and-break" should suit, but it should be remembered that the trembler on a trembler coil is in popular language a Contact Breaker.

In the case of high tension magneto ignition, it is necessary that the circuit of the low tension winding of the armature should be kept closed until the latter has reached a point in its rotation in the field where it cuts the lines of greatest magnetic force. If at this point the contact piece which closes the armature circuit on itself is suddenly opened or broken, the best inductive effect of the magnetically induced current is obtained. Therefore, on these appliances a contact breaker is employed, the points being normally in contact, but suddenly knocked apart by the action of a cam.

Similarly, in low tension magneto ignition it is necessary to have contact broken inside the cylinder, because it is only at the moment at which the circuit is broken that the spark is obtained. The device for obtaining this is situated inside the cylinder, and is as truly a contact breaker as that which we have described in connection with the high tension magneto machine. For the action of these contact breakers see Ignition.

Contact Maker—A mechanical apparatus for making and breaking the low tension circuit of the electrical ignition system: an automatic switch, which alternately completes and

interrupts the current flowing from the battery or accumulator to the coil.

There are two main types, namely, (1) the system in which a trembler or blade makes contact with a platinum pointed screw, and which is often differentiated by the term make-and-break; (2) the system in which a wiper makes contact by rubbing against a brass segment inserted in a fiber case, but in metallic connection with the axle on which the same revolves.

1. The Spring Blade Type (Make-and-Break)—Messrs. De Dion-Bouton were the early exponents of this system. The

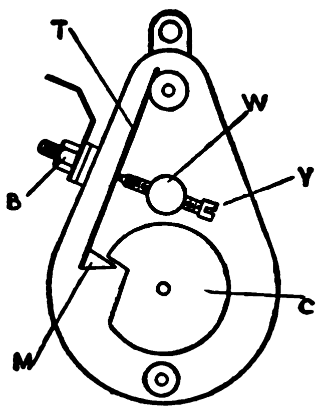


Fig. 1.—Contact Maker Fitted to the Earlier Single-Cylinder De Dion Motors.

type is now obsolete, but as it was fitted to thousands of cars, many of which are at present in use and has all the elements common to the present De Dion ignition system, the cycle of operations may be just as readily grasped. The contact maker is operated by the two-to-one shaft. A pear-shaped metal base plate carries the studs to which are secured the steel contact blade T and the platinum tipped screw Y. C is a cam fixed on the two-to-one shaft, and consequently revolves once for every two revolutions of the motor shaft. T is the contact blade. It has a wedge-shaped piece of metal

fixed to one end, and when the wedge rests in the center of the slot, as depicted in the engraving, the center of the contact blade should be in contact with the end of the screw marked Y.

Now, supposing the switch to be in position, the current flowing through the coil from the battery will run through the stud B and stud W (which are in contact inside the

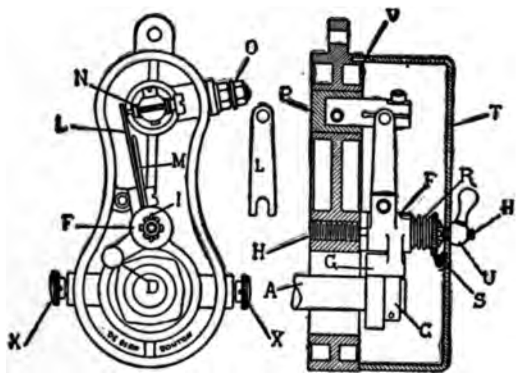


Fig. 2.—Sectional View of Contact Maker Fitted to Later Single and Four Cylinder De Dion Motors.

A. Cam shaft.
D, Tumbler type cam.
F, Oscillating contact arm.
G, Side view of F.
H, Stud screw and spindle on which F works.
I, Pin with recesses for lockings.
L, Contact blade,
M, Do., secondary blade.
N, Adjustable contact screw.
O, Circuit wire terminal.
P, Insulator.
R, Adjustable spring for F.
S, Notched nut for same.
T, Dust cap over contact makes.
U, Finger nut for do.
V. Metal plate of do.
X, X, Spring locking bolts.

base plate), and thence through the screw Y to the contact blade T when the points are brought into contact. From the contact points the current will flow to earth by the base plate, and so through the frame back to the negative pole of the battery, which is grounded to the frame by means of a wire, thus completing the circuit.

When the engine is working, the cam C will, of course, be revolving, and the wedge at the end of T will rest on its periphery, except at the place where the notch occurs. Conse-

quently, it will be seen that it is only when the wedge M, at the end of the blade T, falls into this notch that the circuit path for the current is established, and will continue as long as the blade and screw are in contact. The reader should note the exact position of the wedge piece, as shown in the illustration, for it is essential to the correct working of an engine fitted with this kind of contact maker that the blade should not fall any deeper in the notch than there shown. More detailed reference to the subject will be found under Ignition and Repairs and Adjustments. Popularly the device is known as a Contact Breaker.

The contact maker shown in diagram Fig. 2 was fitted to all later De Dion motors excepting the two-cylinder models, but in the case of the single-cylinder motors the tumbler block has only one cam, whereas in the diagram four will be noticed, that being the type used on the four-cylinder engine. This has what is known as synchronized ignition, as it insures exact accuracy in firing the gases in the respective cylinders.

The action is the reverse of that used in the previously described pattern, the contact blade L being pressed against the point of the screw N by means of the crank F and influenced by the cam-like action of the tumbler D. Inserted in, and attached to, the boss of the lever F is a spring R, the tension of which is adjustable by the nut S. The object of the spring is to keep the end of the oscillating contact arm F always in contact with the periphery of the tumbler D. The contact maker is held in place by the bolts X, X. These in turn are pressed home by springs inserted in the recesses of the bosses at X, X. Only one circuit wire O—the positive —is needed, the return of the negative current being taken through the metallic plate of the contact maker itself.

2. The Wipe System—In this system of making contact some form of rotary wiper or contact block is caused to rotate around and in contact with an insulated disk, on which are arranged, at the proper intervals, insulated metal segments. When the wiper comes into contact with any of these

segments the metallic circuit is completed and the current through the primary coil is carried to earth. It is often erroneously referred to as the commutator, generally in order to distinguish it from the make-and-break system of contact maker. It takes the form of a circular block of insulating material, and is mounted on the timing or two-to-one shaft. Into the circumference is let a small piece of brass or other conducting material, which is directly connected with the timing shaft. As the fiber disk revolves, it makes contact at different intervals with the brush or the brushes, which are in turn connected with the coil, and so completes the low

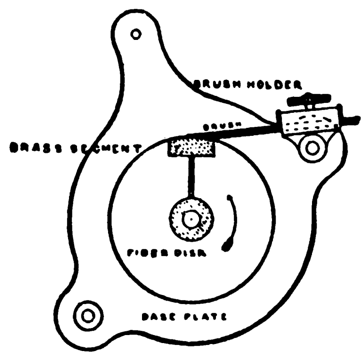


Fig. 3.—The Wipe Type of Contact Maker, Often Called the Commutator.

tension circuit. The current, therefore, flows from the coil through the brushes, the brass insertion, the two-to-one shaft, and the engine, back to the coil. See Ignition.

Another form of wipe contact maker which came into vogue in Europe not long ago is the Castle contact maker. There is an insulated casing of some non-conducting material, which is arranged to be moved slightly around its center by the lever on top which advances or retards the making of contact. In the inner edge of this ring are four metal segments, one of which is clearly shown in the illustration. Each of these four segments is in metallic connection with four terminals, arranged at equal distances around the ring.

The central metal boss or collar is fixed in the end of the two-to-one shaft of the engine, and rotates with it, carrying around with it the roller which rolls in contact with the inner edge of the ring and makes contact with each of the four metal segments in turn. It is mounted on the end of a pivoted lever, and is kept pressed up to the ring by a tension spring. With this arrangement the primary circuits of the four coils used are earthed by a wire leading from the coil to one of the terminals, the current passing to earth through the central rotating boss of the wiper.

A synchronized wipe system used in the case of a typical car consists of an ordinary wipe contact maker, coupled up

Fig. 4.—The Castle Contact Maker for Four-Cylinder Engine.

with and driven at the same speed as the distributer of the high tension current (see Distributer); the latter being in itself a form of wipe contact maker.

Another form of contact maker is correctly called the commutator. This is an appliance almost exclusively used on dynamos and electric motors, and is used to pick up and change the direction of the flow of current in the coils around the rotating armature of the machine. Very often the term is used in connection with contact makers and breakers in

motor ignition appliances, but when so used it is used wrongly, it being a misnomer in this connection, as all the appliances of this type used in motor ignition only interrupt the current and are never used to change its direction.

Contact-plug—A plug used in an electrical apparatus to complete the circuit.

This small brass plug, which the owner of a motor vehicle sometimes secretly removes when leaving his car in the street, etc., is a useful safeguard against theft if the standard design of such plugs be departed from a little by each owner who has enough ingenuity to devise one for himself. A spare plug should be carried, as they are very easily lost.

Contact Points—Used to denote the platinum-tipped points on contact makers and breakers, and in the tremblers of induction coils.

Contact-screw—A screw by means of which contact is secured and the circuit closed in an electric battery.

Contact Series—In electricity, a series of metals so arranged as to produce positive electricity by adjacent contact.

Contact Spring—A spring blade or trembler of a coil, or the spring which keeps the points in contact in the contact breaker of a magneto.

Contact, Wipe—See the Wipe System, under Contact Maker.

Contacts, Electrical, Care of—See Electric Conductors.

Continental Drive—Another name for the double side-chain system of transmission.

Continental Tires—One of the best-known and most successful types of European pneumatic tires. See Tires.

Continuous Clutch—See under Clutch.

Continuous Current—An electric current which is constantly flowing from the positive pole (marked +, or colored red) of the source of supply, to the negative pole, marked — or colored black. A current of this description is neces-

sary for charging accumulators (storage batteries) as well as for use with a coil.

Contracting Clutch—See under Clutch.

Control—The act, power, or method of keeping a motor engine and vehicle under proper regulation, management, or command. Methods of control vary in different makes of automobiles, but are all governed by certain general principles which the novice will do well to acquaint himself with before undertaking to manage a machine. The control system of a modern car includes the hand throttle and spark control levers, the foot throttle, clutch pedal and brake pedal, the gear changing lever and the emergency brake lever, etc., as well as the steering apparatus. All are treated of under their respective headings; also see Levers.

Control—See Operating Mechanism.

Control, Gate—See Control of the Gear, under Change Speed Gear.

Control Lever—A lever used for operating the throttle, gears, clutch, etc. Often applied specifically to the lever by which the change speed gear is controlled.

Control Levers—See under Driving.

Control, Manipulating the—See under Driving.

Controller—A device consisting mainly of a rotating cylinder whereby the different circuits are made for the variable speeds of an electric vehicle. Its operation is regulated by a lever. See Electric Cars, under Motor Cars.

Controller, Electric—See under Electric Motor.

Convection—The act of carrying or conveying. Applied particularly to the transference of heat by means of the upward motions of the particles of a liquid or gas which is heated from beneath. Convection currents are thus produced and the liquid or gas is soon heated all through. Electricity also is transferred or transmitted by means of such currents.

Converter—In electricity, a transformer or induction-coil

used either for raising or for lowering electric pressure. Converters are of various kinds, as multiple, parallel and series transformers.

Cooler, Honeycomb—See under Honeycomb Radiator.

Cooling—There are two systems of cooling internal combustion engines in vogue—air cooling and water cooling. See Air Cooling and Circulation.

The respective merits of air and water cooled engines for automobile use have long been the subject of debate. In regard to the comparative efficiency and power of the two types of engines, a recent writer of authority says:

"Efficiency and power are not interchangeable terms. An engine is said to be most efficient when it produces a horse-power for the smallest consumption of fuel, although the horse-power it develops under such conditions may not be the maximum of which it is capable. A water-cooled engine is designed to work normally at a jacket temperature of about 200 degrees Fahrenheit. In consequence of the cylinder's walls being cooler than those of an air-cooled engine, the incoming charges are not heated to the same extent, consequently a greater weight of mixture is taken in per stroke and the compression also can be carried to a somewhat higher point without preignition. If the temperature rises above that for which the engine was designed two things happen—the incoming charges are rarified by the greater heat and spontaneous ignition is liable to occur before the end of the compression stroke. Both of these things reduce the engine's power. If, however, preignition does not occur it is probable that the fuel consumed per horse-power per hour would be smaller than before, although the maximum horse-power would be less. In the air-cooled engine the compression is made lower purposely, to avoid preignition under ordinary circumstances, and, both for this reason and because the weight of charge taken in per stroke, is less for equal volumes, the power is less than that of the water-cooled engine of the same dimensions. On the other hand combustion is rapid, owing to the high temperature of the surrounding walls, and the

amount of heat converted into work is greater in proportion to the fuel consumption than in the water-cooled engine. These facts explain both the smaller horse-power of the air-cooled engine and its high fuel economy as repeatedly shown in fuel consumption tests that have been made."

Cooling, Air—See under Air Cooling.

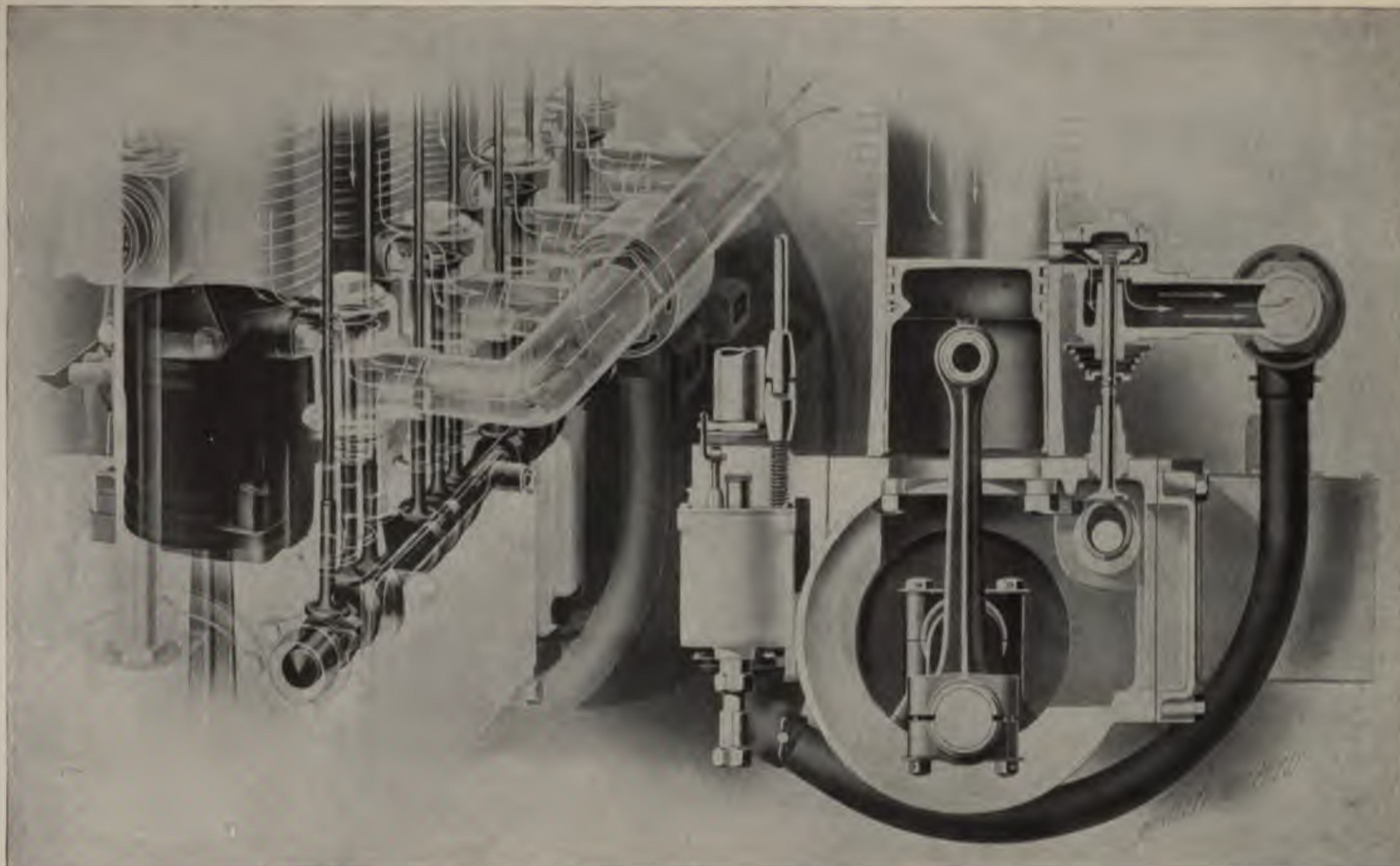
Cooling Brake Drums—The brakes fitted to the road wheel hubs are of the grip block, band, or internally expanding segment varieties. When employed externally the metal bands or rings are so applied that they are made to grip the brake drum from each end, thus making this description of brake effective either backward or forward. On long hills the friction sets up great heat, and to reduce this as much as possible some brake drums are water-cooled. The water, a very small quantity, is admitted automatically to the interior of the drum by the operation of the brake lever from a small special tank. In internal brakes the heating difficulty is overcome by a certain amount of lubrication. All descriptions of back wheel brakes require regular attention and adjustment, for unless they can be operated with the maximum effect obtainable from them they are of very little use.

Cooling, Cylinder—See Cylinder, also Air Cooling and Circulation, the latter containing a description of a water-cooled engine.

Cooling, Water—See under Circulation.

Co-ordinate—A person or thing of the same rank with another and employed or working to the same end. In mathematics, a member of a system of lines to which points under consideration are referred and by means of which their position is determined.

Copal—The resinous product of several tropical trees. When dissolved in linseed oil and diluted with spirit of turpentine it forms a beautiful transparent varnish, much used in carriage work, etc. When properly applied and slowly dried copal varnish is exceedingly durable and hard and takes a fine polish.



The Franklin Air-Cooled Engine.
Sectional View of Cylinder and X-Ray View of Part of Engine.

Cope—In foundry work, the top part of a mold.

Copper—A reddish-colored metal, very ductile, and a good conductor of electricity and heat; principally used in motor car construction for pipes, as it bends rather than breaks when subjected to strain or vibration. It is also used for electrical conducting wires, etc.

Copper stands next to gold and silver in malleability and ductility, and next to iron and steel in tenacity. On account of its electric conductivity it is largely used for induction coils and all kinds of electrical apparatus.

Copper Hammer—A copper-headed hammer is not so brittle as an iron one and will be found useful as part of the motorist's kit.

Copper Sulphate—Blue vitriol, largely used in electro-metallurgy and in the arts.

Copper, White—An alloy of copper, zinc and nickel, resembling German silver. Also called packfong, from its Chinese name.

Copper Wire—See under Wire.

Corduroy Road—A road constructed with logs, laid transversely and close to each other or in contact. It is used in swampy places and derives its name from its ribbed appearance, resembling corduroy cloth. Once experienced by the automobilist on tour it is seldom forgotten.

Core—In molding, the internal mold which forms a hollow in the casting of metals, as the bore of a cylinder, tube or pipe.

Cork—The thick, rough, fungous outer bark of a glandiferous tree, Quercus Suber, growing in Spain and Portugal. Remarkable for its elasticity and lightness and used in carbureter construction for floats and for other purposes in the automobile industry.

Cork Inserts—Pieces of cork introduced into a motor car disk clutch to relieve the strain of gripping and prevent sudden plunges of the car.

Cork, Rock—A variety of asbestos; also called mountain cork.

Corners, On Turning—See under Driving.

Corners, Turning—In turning corners the motorist should invariably keep the pace down or be prepared to do so instantly.

The owner of a heavy car will have a particular reason for slowing on corners, namely, that a tremendous wrench is given to his tires sideways, that is, in such a direction as to pull them from the rim. If a tire cover leaves the rim, the inner tube at once bursts, the rim is nearly sure to be damaged, and the steering is likely to be much disturbed.

No matter what the legal speed limit may be, it is likely to be a highly dangerous pace to maintain in turning corners, both to the driver and to the public.

Corrosion—The action of eating or wearing away by slow degrees, as by the action of acids on metals, by which the substance is gradually changed.

Corrugated Iron, etc.—Sheet iron, etc., pressed into wrinkles or folds so as to give it greater stiffness.

Corundum—Native crystalline alumina, one of the hardest substances known, used when pulverized for grinding and polishing. Emery is impure corundum.

Cost of Operation—In estimating the probable cost of operation of an automobile, as is almost invariably done by the beginner before purchasing his first car, very many considerations must be taken into account. Cost per year and cost per mile may present some curious comparisons when calculated by different owners. Everything depends upon the manner in which the car is used and just comparisons can only be made between cars used for similar purposes and covering a similar amount of mileage.

Compared to horse vehicles, automobiles would be a great deal cheaper were the owner content with one and a half or even twice the mileage he had previously done with his horses. Hence, for business or professional work, a reliable

car shows up very favorably against a carriage. But as a rule the motorist is keen on availing himself of the new means for making long trips, and so spends as much or more than he did before. It is not so much the fuel that costs money—it is such things as the tire maintenance that run up the bill. General repairs and deterioration must also be taken into consideration. Many records have been kept, and they exhibit a disconcerting diversity.

Cotter—A wedge-shaped piece of wood or iron for fastening or tightening a part; a key. Used in machinery for keying rods, etc.

Cotter, Spring—A metal split pin, the ends forming a spring; used in holding parts together.

Cotter-way—The hole which receives a cotter.

Cotton, Gun—See Guncotton.

Cotton, Spun—Cotton prepared in strands for use in calking.

Cotton-waste—Refuse cotton yarn used to wipe oil and dust from machinery and as packing for axle-boxes, etc.

Coughing—A name given to the series of explosions at the carbureter sometimes caused by defective mixture.

Coulomb—The unit of electric quantity, being that conveyed by a current one ampere in strength during one second of time. Named after Coulomb, a French electrician.

Counterbalance—In mechanics, a definite weight added to a moving mass in order to equalize the forces around a revolving shaft.

Countershaft—The name given to the short shaft carrying the gear wheels in the gear box, in contradistinction to the long shaft, which also carries gear wheels, but continues out of the gear box to the differential. The countershaft is also commonly called the jackshaft. See Shafts.

Countersink—To form by drilling or turning, as a cavity in timber or other materials for the reception of a bolt or screw, plate of iron, etc., below the surface either wholly or in part.

To cause to sink in any other body so as to be even with or below its surface.

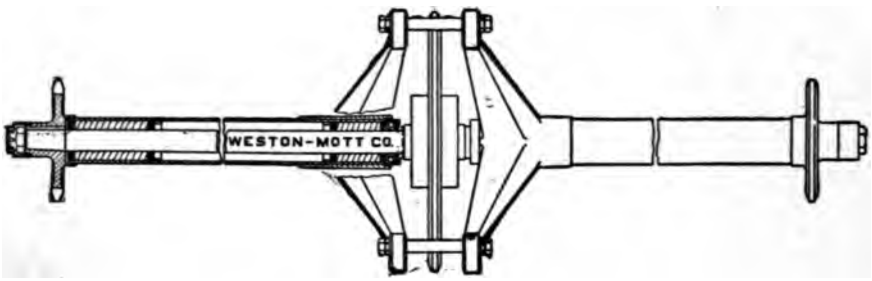
Countersunk Bolt—See Bolts and Nuts.

Countersunk Screw—See Screws.

Counterweight—A weight sufficient to balance and then acting against it or opposed to it. See Shafts.

Coupé—A closed vehicle with an inside seat for two and a seat for the driver outside. Another form of coupé body has seats for four inside and a circular glass front.

Couple—That which links or connects two things together. In mechanics, two equal and parallel forces acting in opposite



Double Side Chain Countershaft.

directions. In electricity, one of the pairs of plates of two metals which compose a battery.

"A couple," says Atkinson, "consists of the whole of the bodies which exist between two zincs, that is to say, zinc, copper, water, zinc."

Couple of Rotations—Two equal rotations in opposite directions about parallel axes.

Coupling—A member used to connect or bridge a space between any two parts that require joining, generally two shafts fixed in line with one another, so that they can be easily disconnected. A general name for a variety of mechanical appliances serving to unite two or more parts or things.

Coupling-box—A box-shaped device for joining the ends of two shafts.

Coupling, Elbow—A coupling jointed or curved at right angles, resembling the bend of an elbow.

Coupling, Flexible—A universal joint; a device for joining pieces of shafting which are not exactly in line or which vary their direction in the course of work.

Coupling, Friction—A form of coupling in which the connection desired is obtained by the friction of the two members.

Coupling, Reducing—A form of pipe coupling for connecting pipes of different diameters.

Coupling Rod—Any rod which couples two moving parts together and transmits the motion between them is known as a coupling rod. In motor vehicle practice coupling rods are used generally in the control mechanism. Instances are the rods which couple up the brake levers to the brakes and the clutch lever to the clutch pedal, and in similar cases the coupling rods which connect up the control levers to the engine-driven appliances, such as the contact maker, the throttle, and the carbureter.

Coupling, Sleeve—A tube or sleeve inside of which the ends of shafting are coupled together.

Coupling, Union—A kind of coupling for connecting tubes without revolving the latter.

Coupling, Universal—A cardan or universal joint.

Cover, Removing the—See under Care and Maintenance.

Cover, Repairing the—See under Care and Maintenance.

Cracked Crank Case—See under Useful Information.

Cracked Piston Crown—See under Compression.

Cracked Piston, Repair of—See Piston, Cracked.

Cradle—A framework for supporting a structure, as in shipbuilding, the frame placed under the bottom of a ship for launching. A framework to support parts of an engine.

Crank—A lever formed at a right angle to a shaft or principal member, used to communicate a rotary or oscillating motion to the same. Cranks are formed by bending or forging to the required shape, or by attaching a separate member at right angles to its principal. They may change circular into reciprocating motion or vice versa. In the case of a bell-crank the crank changes the direction of a reciprocating motion from a horizontal to a perpendicular line, etc.

Crank, Balance—A crank equipped with a counterweight.

Crank, Bell—A lever whose two arms meet or nearly meet the fulcrum. See Crank, above.

Crank Case—The crank chamber.

Crank Chamber—In a motor the case which incloses the crankshaft. See Chamber and Internal Combustion Engine.

Crank Disk—A disk carrying a crank-pin and substituted for a crank.

Crank-pin—See under Pins. This is the part of the crankshaft which is grasped by the big-end bearing of the connecting rod.

Crankshaft—Any shaft turned by a crank, as the main shaft of a gas engine. The number of cranks on the shaft depends on the number of cylinders forming the motor.

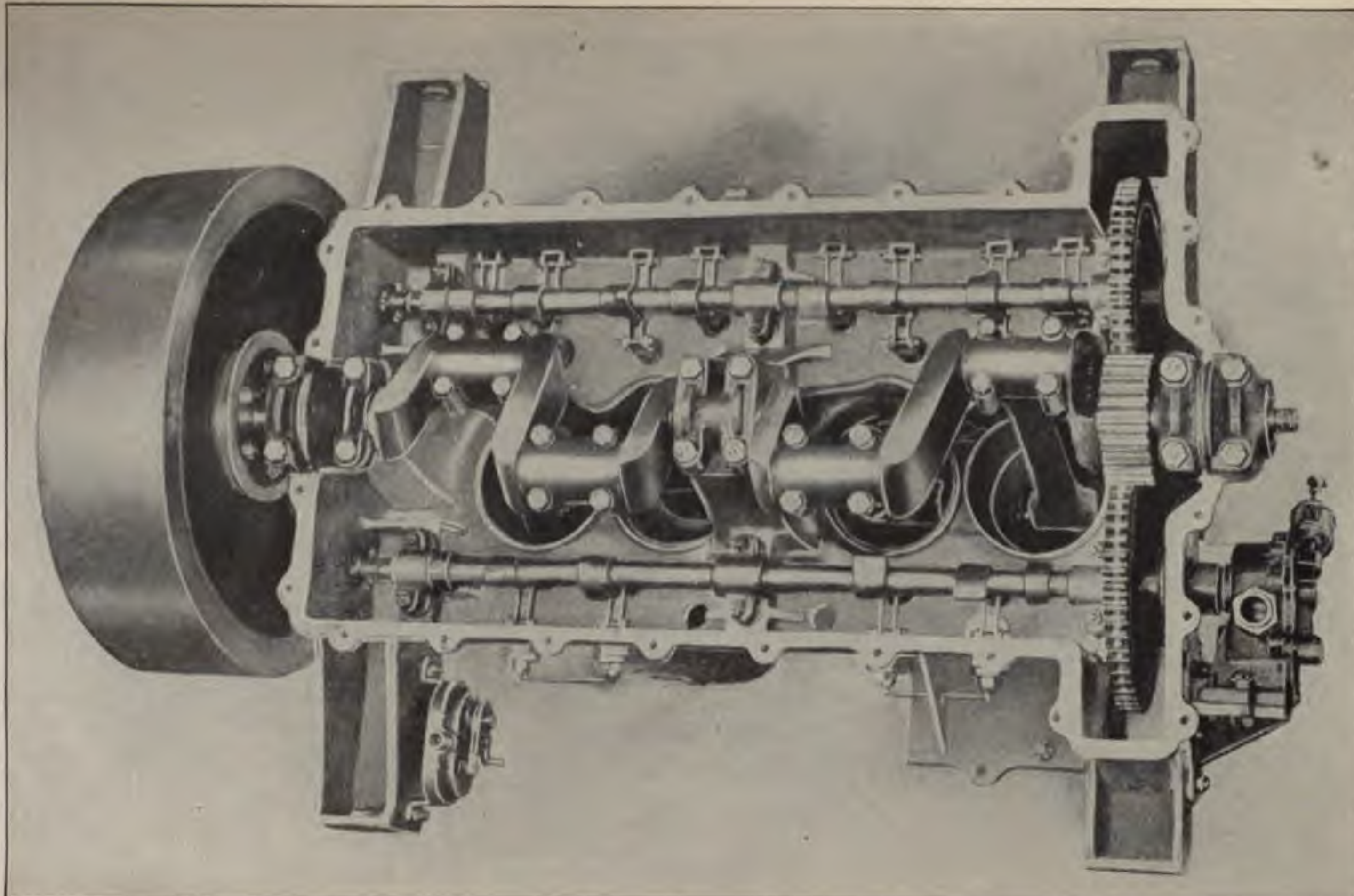
Crank, Starting—The handle in front of a motor car by which the engine is started. It is connected with the crankshaft, and the operation of turning the handle when starting is commonly called "cranking."

Cranking—The act of turning the starting handle of a motor car.

Creeping—The tendency of a tire to move longitudinally around a rim. A similar tendency of the rails on a railroad track.

Cross—A casual electrical contact of two wires by which electricity passes from one to the other.

A pipe-fitting having two arms at right angles to each other—a four-way joint.



American Mors 40-52 H.P. Motor—Showing Crank Shaft, Cam Shaft and Valve Movement.

Cross-cut Chisel—See Tools.

Crossed Belt—A belt which is put on to its pulley wheels so that it runs from the top of one pulley on to the bottom of its opposite pulley. The driven pulley revolves in the opposite direction to the one which drives it. It is used to obtain a reverse motion, or to obtain a greater frictional surface on the pulley wheels.

Crosshead—A crosspiece which forms a sliding guide attachment for a connecting rod, or other similar purpose. It is used principally on steam engines.

Crosshead Pin—Same as Wrist Pin. See under Pins.

Cross-link—In marine engines a link connecting the crank of the main shaft with that of the inner paddle shaft. Also sometimes applied to the draw-bar of a steam locomotive.

Cross Section—The section made by a plane cutting any body at right angles to its axis; also a drawing of the same.

Cross Shaft—See under Shafts.

Cross Spring Broken—See Miscellaneous Roadside Repairs.

Crowbar—A bar of iron sharpened at one end, used as a lever for raising heavy bodies and often fitted with a claw.

Crown-plate—The sheet of metal forming the top of the boiler of a steam car.

Crown-sheet—The sheet or plate forming the top of the fire-box of a steam boiler.

Crown Valve—See under Valves.

Crucible—A vessel or pot made of clay, graphite, platinum or other material, so baked or tempered as to endure extreme heat without fusing. Used for melting metals, ores, etc. The term is also applied to the hollow place at the bottom of a furnace to receive the melted metal.

Crucible Steel—Cast steel made in crucibles. See Steel.

Cryolite—A fluoride of sodium and aluminium found in Greenland and used in the manufacture of aluminum, etc.

Crypto Gearing—Same as Epicyclic Gearing. See under Change Speed Gear.

Cup, Priming—A cup-like device, fitted with a valve or cock, whereby gasoline in small quantities can be introduced into the cylinder of a gas engine.

Cup and Ball Joint—Same as ball and socket joint. See Joints.

Current—A flow of electricity produced by either the chemical action of acids or salts upon two different metals, by friction, or by magnetic influence. See Continuous Current, Alternating Current.

The direction of current can be discovered by finding which is the positive terminal by means of pole-finding paper. The current is said to flow from the positive to the negative.

See also High Tension Circuit and Ignition.

Current, Alternating—See under Alternating Current.

Current Breaker—Any device for interrupting an electrical circuit. See Contact Breaker.

Current-density—The strength of current which flows in any part of an electric circuit divided by the cross-section area of that section of the circuit.

Current, Direct—A current that flows in one direction and does not alternate.

Current, Eddy—A useless current created in a conducting mass by movement through magnetic induction; also called Foucault current.

Current, Inducing and Induced—See under Coil.

Current Meter—An instrument for measuring the strength of an electric current, as an ammeter.

Current, Primary—A current which passes through a primary circuit.

Current, Reverse—An electric current opposite in direction to the normal.

Curve, Steering on a—See Driving.

Cushion—A device which absorbs vibration by some elastic substance, takes up shock, or balances power. Vibration is taken up in a motor vehicle by means of its springs and pneu-

matic tires (where used), which act as a cushion between the car body and the road. See Vibration, Springs.

The shock, or unevenness in the running of the motor, is taken up to a slight extent by the friction clutch, which acts as an intermediary between the engine and the gear.

At each end of the stroke in a steam engine, a certain quan-
gineering knowledge and an experience extending over five
tity of steam is left in the cylinder to cushion the piston and balance the power by absorbing the energy of the reciprocating parts. See Dash Pot.

Cushion, Pneumatic—A vehicle cushion filled with air by pumping, instead of being stuffed with some soft material or fitted with springs.

Cushion Tire—See Tires.

Cushioning—In machinery, the effect produced by a cushion or buffer.

Cutting-out—The term used to describe the action of a governed motor when one or more cylinders are cut out, or put out of action. See Governor, Internal Combustion Engine.

Cut-off—In steam engines, a throttle or device for cutting off the admission of steam to the cylinder when the piston has made a part of its stroke, leaving the rest of the stroke to be accomplished by the expansive force of the steam already in the cylinder. It economizes steam and thus saves fuel.

Cut-off on Steam Cars—Steam is normally admitted to the cylinder by the valve for only a fraction of the stroke. More force, and also more power can be obtained from a given steam engine by allowing the full boiler pressure to communicate with the cylinder throughout 80 per cent. of the stroke in lieu of a smaller fraction, say 30 per cent.

Less force and less power are obtained if the steam is admitted for more than 80 per cent. of the stroke, because of the back pressure exerted by the steam against the return stroke, owing to its not being able to get away in time. Not

only is less force obtained, but the power is got less economically as regards waste of fuel and steam.

When steam is admitted for 80 per cent. of the stroke, the increase of power resulting therefrom is by no means proportional to the increased expenditure of fuel, compared to the case when steam is admitted for 30 per cent. of the stroke.

The fraction of the stroke at which the steam is no longer admitted is called the cut-off.

When the cut-off is at one-third stroke the steam let in during that one-third goes on expanding during the remaining two-thirds, and by its expansion does useful work. It loses its high pressure and its high temperature, and discharges itself to atmosphere after giving the engine the benefit of much of the heat the boiler has put into it. When the cut-off is earlier than one-third stroke, the advantage of expansion is counterbalanced by another phenomenon. For example, if steam is admitted for only one-tenth stroke, and is expanded to ten times its original volume, it will in expanding cool the walls of the cylinder so much as to cause the fresh charge of steam of the next stroke to condense in lieu of expanding and doing work. Therefore, the cut-off, which is adjusted by the driver, to be as early as possible compatible with traveling at the speed he requires, has certain definite limits for economy, namely, between one-tenth and eight-tenths stroke.

If the amount of work becomes very great, as on steep hills, the driver sacrifices some economy of steam and gets the increased effort by giving a late cut-off, say up to 50 per cent. of the stroke; 75 per cent. is about the extreme limit. If he cuts off later than this, he not only gets a less strong effort, but he also uses more steam. If we wish to economize in steam and fuel, as every intelligent motorist should, we must work between the limits of 25 per cent. and 80 per cent. The only means of getting further economy and more expansion, corresponding to an earlier cut-off than 25 per cent., is to get a different motor, one which works "compound," that is, a motor in which the cooling effect on the cylinder of the

extra expansion is got over by carrying out the extra expansion in a separate cylinder set aside for the purpose.

Cut-off Plug—A contact plug by the withdrawal of which from an electric switch the battery can be disconnected. Used as a means of protection against unauthorized interference with motor cars left standing alone.

Cut-out—A kind of switch used in an electric circuit to cut out or disconnect a part of the apparatus from the circuit.

Cut-out, Muffler—See Muffler.

Cycle—An abbreviation for bicycle, tricycle, etc.

In electricity, a complete alternation of a current that changes from the positive to the negative direction and back again rapidly.

In physics, a succession of operations by which an original status is restored; a repeating or recurring series. See Otto Cycle.

Most internal combustion engines in present-day use are of the Otto or four-cycle type. Two-cycle engines, however, have been used successfully, especially on motor boats. In two-cycle engines the charging, compression, firing and exhaust all occur during one revolution of the flywheel, instead of during two revolutions as in the Otto cycle.

Cycle, Carnot's—The series of operations undergone by the substance in the interior of Carnot's imaginary or ideal heat engine.

Cycle, Diesel—A gas engine cycle which differs somewhat from the usual four-stroke or Otto cycle, though only one stroke in every four is a power stroke. In the Diesel engine fuel oil is blown into the cylinder by compressed air.

Cycle, Motor—See Motor Bicycle.

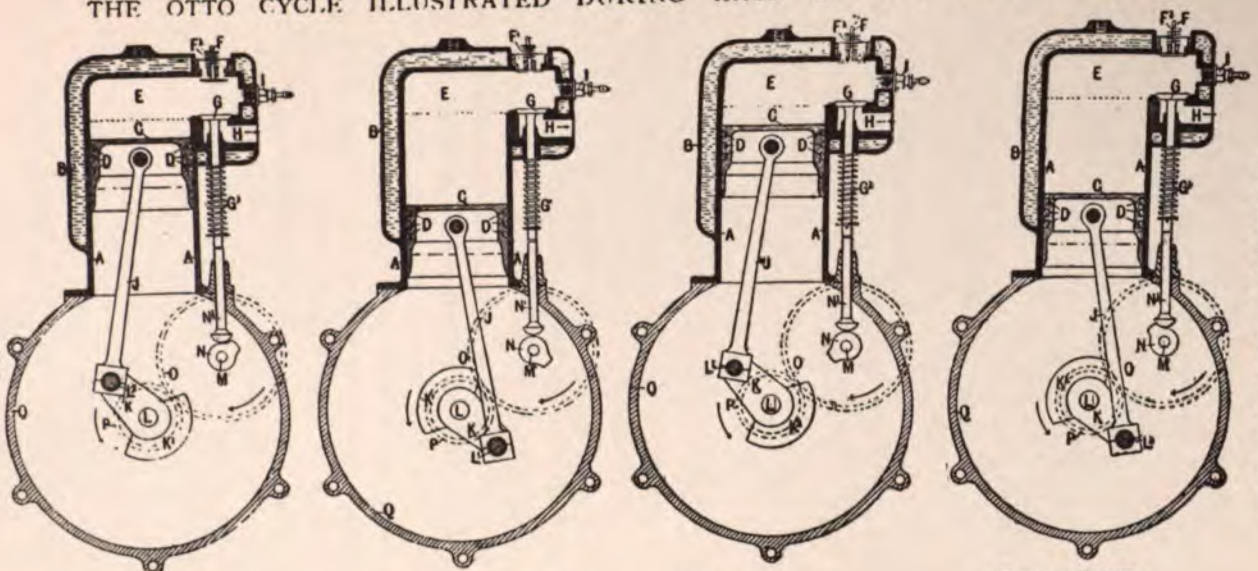
Cycle, Otto—The sequence of operations in a four cycle internal combustion engine, as follows:

1st, Induction, or the drawing in of the gas.

2nd, Compression—The gas is compressed in the cylinder in order to use its expansive force to better advantage.

3rd, Firing—The compressed gas is ignited in the cylinder,

THE OTTO CYCLE ILLUSTRATED DURING EACH OF THE FOUR STROKES.



Suction Stroke.
Inlet valve open.
A A, cylinder walls.
B, water jacket.
C, piston.
D D, piston rings.
E, compression space.
F, inlet valve.

Compression Stroke.
Both valves closed.
F¹, inlet valve spring.
G, exhaust valve.
G¹, exhaust valve spring.
H, exhaust outlet.
I, sparking plug.

Working Stroke.
Firing of mixture.
J, connecting rod.
K, crank cheek.
K¹, crank balance weight.
L, crankshaft.
L¹, crank pin.
M, half-time shaft.

Exhaust Stroke.
Exhaust valve opens.
N, exhaust valve cam.
N¹, exhaust valve tappet.
O, half-time shaft gear-wheel.
P, crankshaft gear-wheel to operate O.
Q, crank-case.

and, expanding, brings pressure to bear on the piston head, thus revolving the crank shaft.

4th, Exhaust, in which the residuum of the burnt gas is ejected from the cylinder. See Internal Combustion Engine.

These four operations or steps in the cycle—sometimes erroneously referred to as four cycles—complete the true cycle of a gas engine. On their completion all the parts are in the same state as at the beginning and the cycle of operations is repeated time after time as long as the engine is kept at work. The cycle includes two outward and two inward strokes of the piston, or four in all, so that the flywheel is revolved twice during each complete cycle.

Cycle, Steam-Engine—The round of operations by which a steam engine works, including the making of steam, its admission to the cylinder, expansion, action on the piston, exhaust, etc.

Cyclists, Driving Past—See under Driving.

Cyclometer—An instrument which records the distance traveled by automatically counting the wheel revolutions and recording them in terms of miles and tenths, etc. A more correct name is Odometer. See Speed Indicator.

Cylinder—A cylindrical metal chamber. The term is chiefly applied to that part of an engine in which the power is developed. It consists of an iron casting which is bored out to an exact size, previously determined. This bore must be absolutely parallel and have a highly polished surface, as it is within this that the piston works. Around the cylinder proper and in one with it, is an outer casing, and the cooling water circulates between the two. In air-cooled engines ribs, flanges or pins are cast on the cylinder to present as large a surface as possible from which the heat may radiate. The cylinder head usually carries the inlet and exhaust valves. See Internal Combustion Engine.

A cylinder becomes broken in practice from one of the following causes:

1. Faulty casting.

2. Water-jacket broken by frost.

3. Pre-ignition.

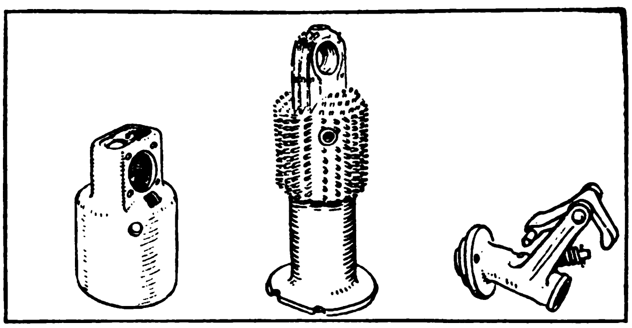
4. Filling up with water while cylinder is red hot from a previous run without sufficient water.

5. Solid piece of metal, such as a valve head, getting between piston and cylinder head when car is in work.

Cylinders may be cast singly, in pairs, or in groups of three or four or more. The advantages claimed for separately cast cylinders are as follows:

1. They are easier to bore out truly in the lathe and to cast.

2. If breakage as above indicated of one cylinder occurs, the replacement is cheaper.



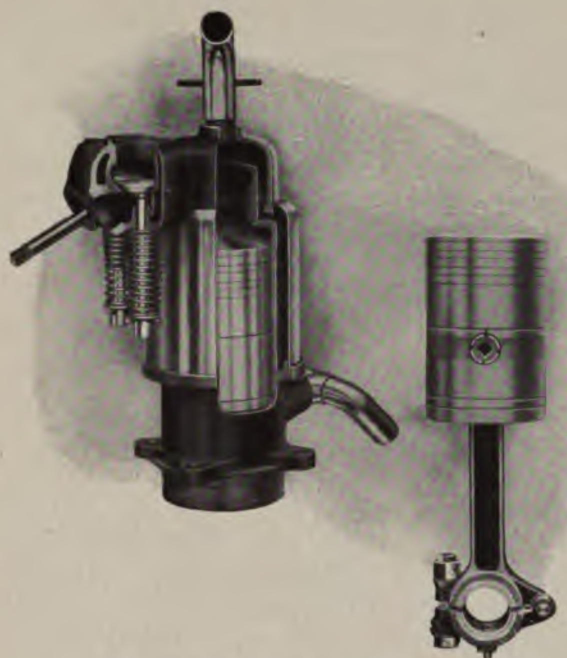
The Frayer-Miller Air-Cooled Cylinder (Separated).

3. The water cooling is claimed to be more uniform, and the expansion with heat is more symmetrical.

4. The extra wide spacing necessitated, while being a waste of car room, nevertheless allows of more perfect arrangement of the engine crankshaft main bearings.

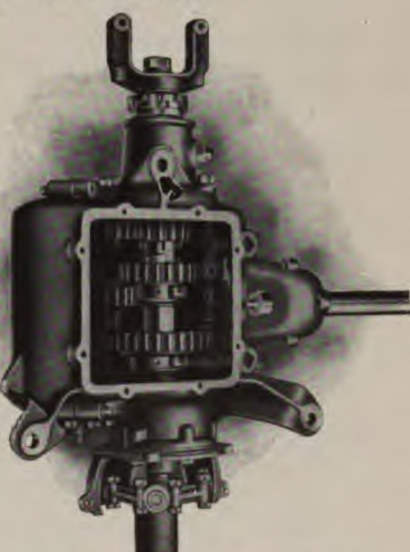
Cylinders in Pairs—If cylinders are cast in pairs, practice shows that the boring can be perfect if the boring-machine tool is up to its work. Engines with cylinders in pairs are cheaper in first cost and lighter for the same cheapness. No appreciable warping with heat has been obtained with certain known makes.

Cylinders in Fours, etc.—In recent years some makers have



Cadillac "Thirty" Cylinder and Piston.

Cadillac "Thirty" Steering Gear.



Cadillac "Thirty" Transmission.
Selective type, sliding gear.

inaugurated the fashion of casting four or more cylinders in one piece. Bonnet space is saved by the more compact design. At least two cylinders are symmetrically cooled, and the others are no worse than when the casting is in pairs. Further weight is saved, both of water and iron; a smooth exterior to the engine is secured which is easy to clean; water circulation is freer; rubber pipe joints are avoided. By the employment of special machinery all the cylinders can be bored out with one setting of the casting.

Patching a Cracked Cylinder Jacket.

Patching a cracked cylinder can often be resorted to if the crack is in a position in which a substantial patch can be applied. When such is the case, a small hole is drilled at each end of the crack, and these holes are filled up with grub or headless screws. Over the crack is now placed a metal sheet, which is attached to the cylinder jacket by a number of screws. These screws should be concentrated as close to the crack as possible, and between the plate and the jacket there should be a layer of packing coated with red lead. This packing should be preferably sheet asbestos, but when this is not procurable thick wrapping paper can be used. As a general rule, an absence of facilities for procuring sheet asbestos means a lack of red lead, in which case the wrapping paper packing may be soaked in lubricating oil.

A Recent Water-Cooled Cylinder.

A photographic illustration on another page gives a good idea of the cylinder construction in a recent Knox water-cooled car, Model "L." The cylinders are cast separately (Fig. 3) and each consists of two distinct castings—the cylinder proper (Fig. 4) and the head (Fig. 5). The water jacket of the cylinder is cast integral therewith, the water entrance being the lowest point and the outlet near its top on the right hand side. In the upper end of the cylinder casting a deep concentric groove is machined (Fig. 4) in which fits a copper asbestos gasket (Fig. 4) upon which is seated a corresponding concentric tongue formed on the bottom of the head, which

is firmly secured to the cylinder by four stud bolts. It is impossible to bring these parts together except in a correct location and with a correct bearing.

This joint it should be noted is not a water joint, in fact there are no water joints in this construction which can possibly occasion a leak into the cylinder.

The head (Fig. 5) is cast integral with the valve stem guides and with its own independent water jacket, and the inlet and exhaust passages from the manifolds to the valves are cored in the head. The water spaces are exceptionally large, the water circulating freely around all the parts mentioned as well as around both valve seats.

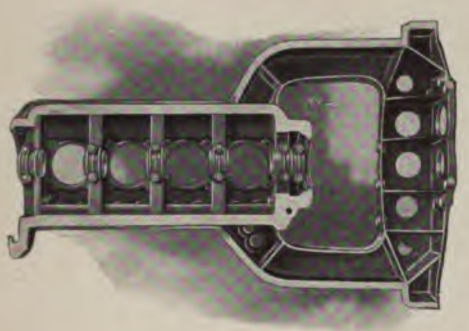
By this simple and convenient construction the makers secure cylinders symmetrical in form and uniform in cross section, which reduces to the minimum the liability of going out of round. Furthermore, they may be easily and accurately machined, the casting being entirely open at both top and bottom. The bottom of the head is also machined so that the entire surface of the combustion space is absolutely smooth and accurate in capacity, giving a perfect balance of the volumes of all the cylinders, which contributes greatly to the sweet and even running of the engine.

In addition to this advantage, the smooth surface of the combustion space is less likely to receive deposits of carbon than an ordinary casting and the absence of sharp points, edges and roughness is a great preventive of premature ignitions.

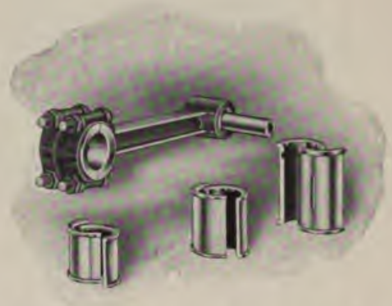
The connection between the water jacket of the cylinder and the water jacket of the head is by means of a single U-shaped hollow casting (Fig. 6) clamped in place on the outside of the cylinder by a single bolt.

In order to remove a cylinder head it is only necessary to unbolt the top water manifold, unscrew the four bolts holding the head to its cylinder and the single bolt holding the outside water connection. If carbon deposits have collected in the cylinder or upon the piston head or cylinder head, they may then be scraped off without disturbing the cylinder

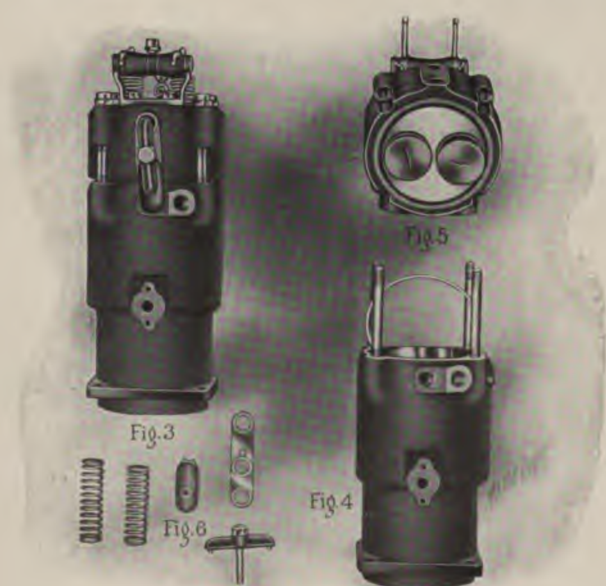
Knox Model "O" Camshaft and Bearings.



Knox Model "H" Air-Cooled
Motor Base.



Knox Model "O" Connecting Rod
and Bearings.



Knox Model "O" Cylinder Construction.
(Water-Cooled.)

proper and both valves may then be ground without danger of any abrasive entering the cylinder.

Cylinder Bore—The interior or cavity of a cylinder; the diameter or caliber of the cavity.

Cylinder Capacity—The cubic contents or volume of a cylinder; the power of a cylinder to contain a certain quantity. Specifically, the volume between the maximum and the minimum stroke of the piston.

Cylinder Cooling—The operation of keeping down the temperature of a cylinder so as to counteract the effects of the heat generated by the firing of the charge. This is accomplished by various methods, generally grouped as air-cooling and water-cooling systems. See Air Cooling and Circulation.

Cylinder Head—That portion of the cylinder above the piston in which the valves and plug are situated, and which includes the combustion chamber wherein the power is developed by the ignition and consequent expansion of gas. In some cases the head is cast separately from the rest of the cylinder.

Cylinder Jacket—An outer case or cover, often cast with a cylinder, designed to prevent the radiation of heat. See Air Cooling, Circulation, Internal Combustion Engine.

Cylinder, Motor—The part of a motor or gas engine in which the piston moves, also including the head or chamber in which combustion of the explosive charge takes place. See Cylinder, Internal Combustion Engine, and Circulation.

Cylinder Oil—A lubricating oil, used on gas engine cylinders. It is a heavy oil but flows freely under the action of heat.

Cylinder, Removal of—See under Engines.

Cylinder, Replacing the—See under Engines.

Cylinder Wrench—A form of wrench adopted for grasping cylindrical rods or tubes; a pipe-wrench.

Cylinders Out of True—See under Loss of Power.

D

Daimler, Gottlieb—One of the justly celebrated pioneers of automobiling and the motor car industry. Born in Wurtemberg March 17, 1834; died at Cannstatt March 6, 1900. He lived to see the gas motor and the automobile introduced into every part of the habitable globe.

For some years Herr Daimler was a partner of Herr Otto, who gave his name to the Otto cycle in gas engine history and practice. Together they made the first real progress in the development of gas engines. The partnership continued until Herr Otto devoted himself particularly to stationary engines while Herr Daimler applied the explosive motor to locomotion. The first Daimler motor—a single-cylinder vertical engine—was produced and patented in 1885, and proved successful. At the Paris Exposition of 1889, he exhibited a Daimler motor applied to a street-car, and it attracted widespread attention. His earliest machine was a forerunner of the modern automobile, embodying—though in an elementary form—practically all the main points of the modern vehicle.

The earliest Daimler engine was an air-cooled engine, air being forced by a rotary fan through an air jacket surrounding the cylinder.

Damper—A device to stop the vibrations of a magnetic needle; also applied to any frictional device which retards and reduces oscillation, bouncing or recoil.

Damping—The act of checking or restraining motion, especially an oscillatory or vibratory motion, as by frictional devices.

Damping Devices—Mechanical devices for checking or reducing the effects of the recoil of a motor vehicle on its ings, as by introducing friction in the working of the

ous Hills, Climbing—Those who have cars on which not hold well backward will find it advisable

when they come to very steep hills to drive the car up backward if they have the least doubt as to the ability of their engine to climb the grade successfully. If they run up backward they not only have the full power of the brakes available if required, but what is perhaps still more important to the majority, the car is facing forward should it show the least tendency to get out of hand.

Everybody who has had any driving experience can steer a car backward at a slow speed safely, but very few are safe if it is running at any pace, and should the car fail to climb a hill and the brakes be weak, there is always a possibility of running down the decline backwards, and if it once fails to obey the brake, the chances are that it will gather speed and the driver will be compelled to take the bank or ditch to avoid worse trouble lower down when his speed has increased. Some of the more dangerous hills, too, have no convenient bank, and the road may be embanked considerably, so that there is only a fence or a mound between it and a very considerable drop. As a matter of fact, no car should be made which has not brakes which will hold it backward and forward on any hill, however steep it may be.

Daniell Cell—An electric cell in which the anode is zinc, the cathode copper. The zinc plate is surrounded by a porous cup filled with dilute sulphuric acid or a zinc sulphate solution; the copper electrode is immersed in a solution of copper sulphate. The chemical action results in the production of electrical energy which accompanies the current when the external circuit is closed. This is typical of all cells. The ordinary Daniell cell has a voltage of 1.08. See Depolarizer.

Dangers from Gasolene Leakage—See under Gasolene.

Dash-board—The board or screen usually of metal placed on the forepart of a motor car and serving not only as a protection for the driver but to carry important light parts of the control apparatus, including indicators, lubricating devices, spark-coil, etc.

Dash-pot—When the motion of any piece of mechanism,

either of great weight or at a high speed, has to be suddenly arrested, a dash-pot is used.

One form of a dash-pot consists of a cylinder fixed in such a position that a piston on the moving piece enters it at the time when that movement has to be arrested. The piston compresses the air in the cylinder, which acts as a cushion, arresting the motion without shock. A small orifice in the end of the cylinder through which the air can escape will retard the speed at which the movement is arrested, and by altering the size of this orifice the time in which the mechanism can be brought to rest is regulated. Used in some carbureters and in some cases to prevent the bumping of springs.

In general, a dash-pot may be described as an apparatus for deadening the blow of any falling weight and preventing any jar in the machinery, as in the valve-gear of an engine.

The term is also applied to an apparatus for regulating the motion of an arc lamp and other electrical appliances.

Davit—A curved iron upright on a ship's deck constructed so as to swing a boat or other load over the side or stern of the vessel and permit its being lowered into the water; it is a species of hoisting crane, equipped with sheave and pulley.

Davy Lamp—A safety-lamp invented by Sir Humphrey Davy and called after him. Used by miners and others to prevent explosions from firedamp, etc.

Dazzled, To Prevent Being—See under Driving.

Dead—Motionless; inert; not transmitting power or motion. Used of idle machinery or of parts that take no active share in transmission of energy.

Dead Axle—See under Axles.

Dead Center—In mechanics, the condition of an engine's connecting rod and crank axle being in a straight line; the dead point.

Dead Heat—In a race a heat in which the contestants finish even.

Deadlight—On shipboard, a strong shutter fitted to a cabin window or porthole to shut out water in stormy weather.

Dead Point—Same as Dead Center.

Dead Weight—A heavy or oppressive burden. The unvarying weight of a motor car and its appurtenances, as distinguished from its weight when loaded with passengers or freight.

Deadwood—Useless material.

Deal—A board or plank. The name is chiefly applied to boards about seven inches in width and of various lengths over six feet.

Deca—A prefix, from the Latin "decem," ten, signifying ten or a multiplication by ten; as in decagram, a weight equal to ten grams; decaliter, a measure of capacity equal to ten liters or 610.23 cubic inches or 2.64 United States wine gallons.

Decarburize—To deprive of carbon, wholly or in part, as in making steel. The process of decarburization is used to transform cast-iron into steel or into malleable iron.

Deci—A prefix, from the Latin decimus, tenth, signifying a tenth part, as in decimeter, the tenth part of a meter or 3.937 inches.

Deck—A horizontal platform or floor extending from side to side of a vessel. The roof of a railroad passenger car.

Deck-beam—A T-shaped iron beam having a slight enlargement opposite the flange.

Declutch—To disengage a clutch by operation of the lever controlling the same.

De Dion, Marquis—A celebrated French inventor and engineer, who, with M. Bouton, developed Daimler and Otto's system for internal combustion engines. They were the pioneers of the motor cycle and light car movement.

Defective Insulation—See Misfiring through Defective Insulation, under Ignition.

Deflection—A turning from a true line or a regular course; deviation. In mechanics, the bending of any material exposed to a transverse strain.

Deflector—One of various appliances used in producing deflection, as the diaphragm of a boiler furnace, the controller of the nozzle of a hydraulic mining machine or a baffle-plate. See Baffle-plate.

A spraying-cône is sometimes called a spray deflector. See under Cone.

Deformation—The condition of being deformed; altered form; transformation. Any change of shape of a body or surface without changing the continuity of the parts or altering their size; mechanical strain.

Degree—The 360th part of a circle.

In the United States and in Great Britain and Ireland degrees of heat are expressed in Fahrenheit units, in which 32 degrees are taken as the freezing point of water and 212 degrees the boiling point. On the continent of Europe the Centigrade scale is principally used. It is the difference between the freezing and boiling points of water, divided into 100 parts or degrees.

Delivered Horse-power—The actual work, expressed in horse-power of 550 foot-pounds per second, performed by an engine, as distinguished from its nominal calculated or commercial horse-power.

Delivery—The act of surrendering, giving up, sending forth or discharging; also the capacity for discharging or pouring out, as the delivery of a pump.

In founding, the bevel or free play given to a casting.

Delivery of a New Car—Many automobilists like to take delivery of a new car at the factory, and not infrequently they drive home on it without a man from the works accompanying them. This is all very well if they have had a little experience, but there are certain things they should make a point of doing before starting on the journey. In fact, they are well advised to attend to these things personally even if the factory driver goes with them, because it is well for them ·emember that they have paid for the car, and the makers longer wholly responsible.

When trouble occurs with a new car it is almost invariably due either to lack of lubrication or to faulty adjustment of some part. By far the most common is lack of lubrication. It is quite easy for this to be overlooked in a busy factory. In the first place, for his future guidance, the motorist should be acquainted with the system of engine lubrication, and, having had this explained to him, he should proceed to verify by the oil level cock in the crank chamber that this has the necessary supply. If for any reason he cannot satisfy himself in this matter, he should persist in oiling the engine till it smokes, but it is only under exceptional conditions that this form of verification is necessary.

Then he should proceed to the gear-box. Many owners have been assured before now that a gear-box was full of oil or a mixture of oil and grease, as the case may be, but have become so hardened in these matters that they are equally surprised whether they find the gear-box full or empty. If the car is chain-driven, one can see whether there is any lubricant on the chains, but if it is gear-driven it is most imperative to see that the back axle and its differential case are thoroughly oiled. The front wheel caps should be taken off to see that there is grease in the bearings, and all the joints and working points should be carefully gone over with an oilcan, as they are almost sure to be stiff.

Particular attention should be given to the steering, not only to seeing that there is plenty of lubricant in the steering box, but that all the joints of the steering gear are properly oiled.

Having attended to the lubrication it is always well to make sure that there is water in the radiator, and that the gasolene tank is full. The engine should then be started and the car driven a little way. See that everything is working; see that the steering is in proper order, and that there is an equal lock both ways. The brakes should also be tested.

If the vital points we have mentioned are seen to there are not likely to be any unsuspected difficulties on the first journey, though we should perhaps add a word as to tires. See that

these are all inflated to full pressure, and do not take the reading from the pump gauge but from a proper tire gauge, which will give the actual pressure in the tire, and not the resistance of the valve.

Delivery Valve—See under Valves.

Delivery With Electric Vehicles—See Trucking and Delivery; also Electric Cars.

Demagnetize—To deprive of magnetism or magnetic polarity. The induction of a magnet on itself always tends to diminish the magnetization and results in demagnetizing.

Demagnetization—When after a couple of years' use a magneto begins to give poor sparks particularly at slow speeds and at starting, the magnets (which lose their magnetism by vibration and heat) can be sent to the makers to be remagnetized, after which they are as good as ever.

Denatured Alcohol—Ethyl spirit or alcohol rendered unfit for drinking. Methods of denaturing alcohol are prescribed by United States regulations and similar governmental rules in other countries. See under Alcohol.

Densimeter—Same as Hydrometer.

An instrument for measuring the specific gravity or density of liquids, taking water as 1. It shows the difference in weight between the liquid being tested and its equal bulk of water. Used for testing volatile spirits to determine approximately their rate of evaporation.

The specific gravity test is, however, more or less fallacious. The real test for spirit is its volatility or evaporating efficiency. A petroleum which is homogeneous, containing no constituent hydro-carbons which boil at a temperature higher than 300 degrees Fahrenheit, and which distil over within less degrees of heat than another brand, may give better evaporative results irrespective of its specific gravity.

Density—The quality of a body or substance which depends upon the close cohesion of its molecules, measured by the mass of matter per unit of volume. The relative density of

a substance is generally called its specific gravity. See Specific Gravity.

Density, Electric—The quantity of electricity per unit of volume or area.

Dent—A hollow or depression made in the surface of a solid body; an indentation.

Dents in Tubing—In some cars of the older type it was unfortunately the practice to put many of the tubes, such as those conveying the exhaust gases and the water for cooling, in the most inaccessible places. These being in such a position are frequently indented by stones being thrown upon them from beneath the wheels. These dents cause considerable restriction to the free passage of the gas or water, as the case may be. The removal of such dents is a matter of some difficulty, as a general rule. A method by which the difficulty may be overcome to a very great extent is the following: Take two hammers—one preferably with a soft face, or an ordinary wooden mallet, the other of the smooth-faced engineers' type. The soft hammer should be held against one edge of the dent, and with the steel hammer light quick blows given on the opposite edge of the dent. The blows should be given with a drawing motion, so that the face of the hammer passes along the edge of the dent. As the one hammer travels around the dent, the other one should be moved in unison with it, so that it is always opposite the point where the blows are being delivered. By continually working around the edge of the dent in this manner, it will be found that the tube can be restored to very nearly its original section. This "tip"—which is not, we believe, very generally known, even in workshops—is one in constant practice among military armorers, this being the method resorted to for taking dents out of sword scabbards.

Depolarization—The process of freeing the plates of a primary battery from hydrogen, which tends to impede the action of the cells and reduce the current.

When the chemical action takes place in a primary battery, producing the electric current, bubbles of hydrogen gas will

collect at the carbon plate, and prevent the electrolyte having free access to it, or will cause local action between the carbon plate and the hydrogen gas. In order to remove this, primary batteries are provided with a chemical which is used as a depolarizer; that is, something which will combine with and so get rid of the hydrogen. Such substances are manganese dioxide in Leclanché or dry type batteries, or chromic acid in primary batteries used for charging accumulators (storage batteries).

When a primary battery becomes run down, it has probably used up all the depolarizing solution, and converted it, so that it is necessary to renew the solution. Polarization should not be confused with the term "local action," which is the action on zinc plates caused by impurities in the metal. If a zinc plate is put into acid, it will immediately begin to fizz and bubble, owing to the local action, which is caused by the acid acting upon the zinc and small particles of other metals which may be present. If the zinc plate were chemically pure there would be no such action, or if the zinc plate were entirely equal in impurities over its whole surface. As it is not practicable to get chemically pure zinc for ordinary use, the expedient is resorted to of making the entire surface of the zinc equally impure, by rubbing it with mercury. This is called amalgamating the zinc plate, and is done by dipping the plate in acid and rubbing on the mercury, or by immersing the zinc plate in a bath of acid with mercury. When the plate is completely amalgamated, it can remain in acid without any action from local causes until the current is taken from the cell, when the plate is gradually consumed by the chemical action which is producing the current.

Depolarizer—A chemical solution employed in primary cells. When a primary cell has been discharging continuously for some time a film of hydrogen gas is collected on the negative plate which interferes with the chemical action going on, and reduces the E.M.F. of the cell. The depolarizer is a solution in which the negative plate is immersed, to chemically absorb the gas and so prevent it settling on the plate. In the case

of a Daniell cell the depolarizer consists of a solution of copper sulphate. See Battery.

Deposit—Any matter laid or thrown down or lodged; especially matter settled by precipitation, as a deposit of carbon in the cylinder, a deposit of copper in electrolysis. Lime is frequently deposited from the water used in boilers and is called boiler scale or fur. It is also sometimes found as well as carbon in motor cylinders.

Deposit, Cylinder—This is due in gasolene engines (a) to over-lubrication; (b) to using too "rich" a mixture, that is, burning too much gasolene for the quantity of air admitted. Its formation is usually accompanied by the smell of partly unburnt oil. Its evil effect is that the deposit gets hot and preignites the charge. It is first detected by "self-ignition," that is the engine fires after the spark has been cut off, or by failure to start because some of the deposit is on the spark plug.

It is possible to run with a dirty cylinder by using a poor mixture, that is a mixture with too much air for full power, as this will help to avoid preignition.

The deposit is easily removed by careful scraping, by hand, of the inside of the cylinder. See Intensifier, for obtaining an ignition spark, even when cylinder and spark plug are dirty.

Deposit on Piston Heads—See under Engines.

Derby—Originally in England, an annual sweepstake race for three-year-old thoroughbred horses. Now often applied to other races of an annual character.

Descending Hills—See To Avoid Sideslip Downhill, under Driving.

Design, Simplicity of—See remarks under Cleanliness.

Detachable Body—See under Carriage.

Detachable Rim—A rim that may be removed at will. See under Rim.

Detector—A small form of galvanometer to indicate the passage of a current of electricity, showing its direction but not its strength.

Detent—Anything that checks or stops motion, as a lever, pin, pawl or stud forming a check in a machine or part of a machine. The detent of a ratchet wheel prevents back motion.

Detent Pin—See Pins.

Detroit—The chief city of the state of Michigan, favorably situated on the Detroit River between Lakes Huron and Erie and rapidly adding to its fame as an important center of the automobile industry in America. Many of the best-known makes of American cars are manufactured in Detroit or its immediate vicinity, and numerous establishments for the manufacture of automobile parts, accessories and supplies are found within its corporate limits. It is a city of clean, well-paved streets in which the automobile reigns supreme.

Devil—An English name for a contrivance for preventing a car from running backward downhill. See Sprag.

Diagnosing Causes of Stoppage—When an engine stops work, and the owner diagnoses, or believes he diagnoses, the reason, it is well to test that diagnosis first before going on to anything else, for if, say, he cleans and tests his sparking plugs, inspects and tests the valves, agitates the carbureter, varies air feed, and fills up the gasolene tank all before he restarts the engine, he is then quite innocent of the real stopping reason, and has not advanced in knowledge. Whereas if the inducements to restart are tested one by one, he discovers what was really the cause of failure, and is far more likely to recognize it at once should it exercise its baleful influence at any future time.

Diagram—Any mechanical drawing giving only the outlines or essentials, often crude; also a map or plan, as distinguished from a drawing in perspective.

A force-diagram is a diagram in which the lines of action of forces are represented by lines.

An indicator-diagram is the automatic drawing made by a steam-indicator, indicating distances of piston-travel, pressures and total work performed by the piston during its stroke. See Manograph.

There is a special difficulty in obtaining the indicator-diagram of high speed gasolene engines owing to the inertia of the parts of the indicator and other good reasons.

Indicator-diagrams are not always clear, but if they appear in any abnormal manner, it is a certain sign that something is wrong.

For instance, if the expansion curve suddenly fell to the atmospheric lines about half way through the stroke, it would show the exhaust valve timing was wrong, and that it was opening much too soon.

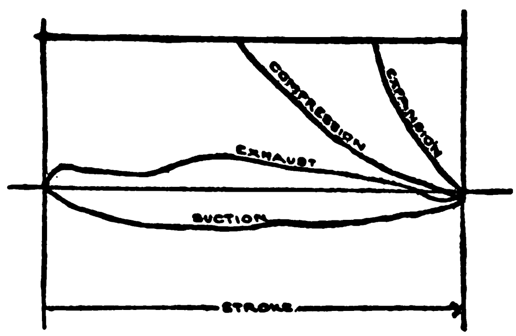


Diagram Obtained with a Light Spring, Showing Suction and Exhaust Accurately.

If the maximum pressure occurred at the end of the stroke, just before the exhaust valve opens, it would show that the firing was much too late. These are merely given as examples of what may be learned from inspection of the diagrams, but the sources of error in the diagrams are so numerous that only experienced people can draw correct deductions.

To Calculate Horse-power.

To calculate the indicated horse-power of the engine by means of a diagram, the following is, perhaps, the easiest method:

Divide the length of the diagram into ten equal parts, placing the division marks so that there shall be half a space at each end. Then draw a vertical line through each mark, and

measure the breadth of the diagram at the first vertical line, then do the same at the second line, and so on, noting the breadth of the diagram at each vertical line. When the breadth of the diagram at each of the points has been determined, add them all together. Let us suppose that they total five inches, then the average breadth of the diagram will be 5 divided by 10 or ½ inch. But the breadth of the diagram, at any point of the stroke, is a measure of the pressure on the piston at that point, and if the strength of the spring of the indicator has been so arranged that every 150 lbs. pressure per square inch on the piston shall be represented by a vertical height of one inch on the diagram then, since the mean height of our diagram is half an inch, the mean pressure on the piston must be 75 lbs. per square inch.

Dial—Any plate or face on which the revolutions or other movements of machinery, etc., are registered by means of a movable pointer or index, as the dial of a steam-gauge.

Diamagnetic—Any substance, as glass, bismuth, zinc, etc., which is diamagnetic in a magnetic field of force—that is, which possesses the property of being repelled by either pole of a magnet and shows a tendency to cross the lines of magnetic force.

Diameter—A line or the length of a line passing through the center of a plane figure or solid terminated by the opposite boundaries. In a cylinder the diameter is the length of the cross-section at right angles to the axis.

The circumference of any circle is obtained by multiplying the diameter by 3.14159.

Diameter of Wheels—See Wheel Diameter, under Wheels.

Diametral Pitch—A mode of expressing the pitch of a toothed wheel in terms of the diameter. It is obtained by dividing the number of teeth by the pitch diameter; thus, the diametral pitch of a wheel 6 inches in diameter and containing 48 teeth would be 8.

Diaphragm—A very thin disk of metal, rubber, or other substance of circular shape, clamped firmly around its edge

in such a manner that it has bending movement towards its center if subjected to pressure there.

In carbureters it is used to allow the suction of the engine to operate a slide for controlling the regulation of the air. The diaphragm is fixed at one end of a closed cylinder of greater diameter than its length. A pipe leads from the cylinder to some part of the suction pipe of the engine, and the suction of the latter causes a partial vacuum in the cylinder. The external atmospheric pressure then depresses the diaphragm into the cylinder, and a rod or lever attached to its center is correspondingly moved, and operates the slides or valve for controlling the air supply. See Carbureter.

Die—A tool or appliance, commonly of hardened steel, used in giving a desired shape to a piece of metal, etc., a female screw for cutting outside screw-threads; a mold or matrix used in forging eyes, etc.; a stamp for milling blanks; an endless knife for cutting irregular shapes by impression, etc.

Diesel Engine—See Cycle, Diesel.

Differential—In mechanics, denoting differences of motion or the results of such differences.

Differential Broken or Out of Order—See Miscellaneous Roadside Repairs.

Differential Gear—See Balance Gear; also Gear, Differential.

Differential Pinion—See Wheel.

Difficulty in Starting—It has been truly said that a gasolene motor is a thing of freak notions; it has been known to be running perfectly all one day and almost impossible to start the next morning, notwithstanding the fact that not a single piece of the mechanism has been disturbed—by mortal hand. Yet, where a motor stops or fails to start, let it be known there is a cause; the chief difficulty for the beginner—and sometimes for the wisest expert—is to locate the cause, which, once discovered, is usually easily remedied. Trouble in starting, except in cold weather, when atmospheric conditions determine things, is usually traceable to some minor disarrangement and probably 90 per cent of all such troubles may safely be traced

either to the ignition system or the carbureter and its very close relatives. Aside from the reasons here given for a motor failing to start as the operator would have it, there have been other reasons and there will in the future be found still more. Ordinarily the operator who has difficulty in starting his motor will find the reason set forth in the paragraphs under this heading; if the reason is still remote the case will probably be a difficult one and beyond the imagination of any man who is any distance from the balky piece of machinery. Difficulties in starting are taken up in their probable order of likelihood.

Ignition.

Batteries Weak—Test each dry cell with an ammeter; if it shows under 5 or 6 ampères, replace it with a new one. Better still, discard the set and put in a new one. If there are two sets and each set is weak, connect the two sets in series, which will suffice for a time. It is well to always carry an ammeter so that in purchasing new cells they may be tested. New ones should test in the neighborhood of from 15 to 17 ampères.

Storage batteries must not be tested with an ammeter or a voltmeter. Attach a wire to one pole and snap the free end across the other pole. If a large, snappy spark results, the battery is all right. A storage battery never should be permitted to be completely exhausted; nor should it be permitted to stand without some use for any length of time, otherwise it may be ruined.

Switch Off—A most common oversight, even with old motorists.

Loose Connections—Battery terminals or wire leading to switch or coil disconnected.—If switch is on and vibrators do not buzz, trace the wires for the disconnection.

Incorrect Wiring—This will not be the case where the motor has been running and no alterations have been made; it may occur when the wiring has been changed or replaced after overhauling. Consult the diagram of wiring as secured from the seller and see that the wiring scheme is correct.

Plugs—(a) Plugs fouled with oil or carbon—Remove and clean.

(b) Points on make-and-break sooted or fouled—Clean with fine file or emery paper.

(c) Short circuit through broken or cracked porcelain—Replace with new plug.

(d) Points too close or too far apart—Reset to have 1/32 inch gap.

Coil—(a) Vibrators stuck—Readjust after cleaning to remove possible pitting or dirt, destroying contact.

(b) Tension of vibrator spring too great for partially run-down batteries.—Readjust to meet battery condition.

(c) Coil wet—Remove and take to coil man for repairs.

(d) Condenser in coil punctured (through use of too high voltage, for instance)—Same remedy.

(e) Wire from battery or commutator disconnected—Replace.

(f) Secondary wire disconnected or broken (but this will not prevent vibrators from buzzing).

Spark Lever—(a) Connections slipped, retarding spark.—Reset as per information obtained when purchasing car.

(b) Connections from spark lever to commutator disconnected—Go over and secure as originally.

Carbureter—Gasolene.

(a) Throttle closed—Open.

(b) Gasolene tank empty—Fill.

(c) Shut-off valve in gasolene line closed—Open.

(d) Water in gasolene tank, carbureter or line—Drain from bottom of carbureter, or disconnect pipe at lowest point, if there is no drain cock, and let about a pint drain off.

In winter water will freeze in carbureter or pipe line and absolutely shut off the gasolene supply.

(e) Dirt in carbureter, choking spray nozzle—Drain carbureter and if necessary take out to clean, being careful not to disturb adjustments.

(f) Float level too high—This will cause flooding of carbureter, too rich mixture and sluggish starting, if any.

Inasmuch as carbureters differ, no rule for changing the float level can be laid down. See Carbureters.

(g) Float punctured or leaky, preventing valve from shutting off and causing carbureter to flood—Secure new float.

(h) Float level too low, causing weak mixture.

(i) Air valve spring tension too great, causing too rich mixture; too weak, causing motor to take too much air and too little gasolene.

Lack of Suction.

(a) Valves stuck, holding open, preventing suction and compression. This will occur in cold weather if the stems are gummed with oil.

(b) Valve springs weak or broken. If weak, stretch out for temporary repair; if broken, remove and place an iron washer over the stem and between the pieces of spring.

(c) Poor compression through fouled valves—Remove and grind. See "Useful Information."

(d) Leak in intake pipe joints—Set up cap screws, nuts or whatever holds pipe to cylinders; if necessary put in new packing of asbestos, with shellac on either side.

(e) Relief cocks open—Close.

(f) Plugs not tight—Screw in close, use copper gasket if plug has shoulder. If threads are worn use litharge and glycerine, in paste, to take up wear, same as plumber would use red lead.

(g) Valve pocket caps or valve cage ring nuts loose—Set down; use litharge and glycerine if badly worn.

(h) Piston rings stuck—Put kerosene in cylinders, leave stand few hours to loosen rings.

(i) Carbureter connection to intake pipe loose—Tighten and put in new gasket if necessary.

In Winter—Cold Engine.

(a) Flood carbureter.

(b) Close air intake with cloth.

(c) Prime cylinders with half teaspoonful gasolene.

(d) Advance spark little more than usual, because of lag in ignition.

(e) Soak cloth with gasolene and put in air intake so gas can be drawn into cylinders.

(f) Keep throttle well open.

(g) Warm carbureter with cloth soaked in hot water; or pour hot water on carbureter, being sure no water gets into air intake.

Valves Set Wrong.

If the valves are set so as to open and close at the wrong time the motor will not start and will not run. Thus it is essential that the valve setting be known and known to be correct.

Dip—Inclination downward; a direction below a horizontal line. The depression given to the axle spindles on which a wheel runs in order that the spokes may travel in a vertical plane.

Direct-acting—Applied to those engines in which connection is made from the piston-rod direct to the crank or plunger without intervening gear.

Direct Current—See under Current.

Direct-draft—Having a single direct flue, applied to steam boilers.

Direct Drive—In a typical gear-driven car the variable speed gear is devised with the clutchshaft and gearshaft in line; and for the top speed these two shafts are coupled together and rotate as one, the power being transmitted direct instead of through spur wheels. There are usually three speeds forward and one reverse, the two lower speeds and the reverse being obtained by the spur wheels. The construction may be described thus: The rear end of the clutchshaft and the forward end of the gearshaft telescope into each other. The gearshaft is made of square section, and on it is mounted a sleeve carrying two spur wheels of different sizes. On the forward end of the sleeve are two strong dogs or projections,

while on the rear end of the clutchshaft is fixed a wide spur pinion having two recesses in its back face. A second gearshaft is mounted parallel to the first, and on this are fixed three "forward" spur wheels corresponding in diameter to the two on the first gearshaft and the one on the clutchshaft.

For the top speed the clutchshaft and first gearshaft are coupled together by moving the sleeve forward until the dogs thereon enter the recesses in the spur wheel on the clutchshaft. This is the "direct drive," and is so called because no power is lost by transmitting it through the second gearshaft; indeed, in some forms of the gear, the second shaft is not even rotated when the top speed is "in." For the two lower speeds, the sleeve is moved back so as to disengage the dog clutch and bring one of the wheels on the sleeve into gear with the fellow wheel on the second shaft. Now the power is transmitted from the pinion on the clutchshaft to the largest wheel on the second shaft, and then back from one of the smaller wheels on this shaft to the wheel in gear with it on the sleeve, and so to the first gearshaft. This is not unlike the "back gear" of a lathe. For reversing purposes a fourth wheel on the second shaft is geared with the larger wheel on the sleeve through an intermediate wheel.

The direct drive when used has the advantage of reducing the noise made by motor machinery and, more important still, it adds to the efficiency of the machine. See Change Speed Gear, also Gear and Gearing.

Direct Process Iron—Workable iron obtained from the ore by a single process of smelting.

Dirigible—A balloon or airship capable of being guided, steered or controlled. In the remarkable recent development of aerostatics the adjective dirigible applied to a balloon or inflated apparatus like the Zeppelin airship, has become a substantive and the device is often called a dirigible.

A similar case is seen in the adoption of the word automobile as a noun.

Discharge—A throwing out, vent or emission. Applied to

the flowing out or issuing forth of a liquid as a discharge of water, also to an electrical battery or cell to signify the removal of the charge by forming a communication between the positive and negative surfaces.

Discharge-box—The muffler or silencer of an automobile. See Muffler.

Discharge, Electrical—The flow of an electrical current from one conductor to another.

Discharger—An instrument or device by means of which the electricity is discharged from a cell, battery or other charged body.

Discharging—The act of permitting the electric current to flow out from a battery, cell, etc.

Disengage—To release or liberate, as to disengage a clutch from contact with gear-wheels.

Disengaging Gear—See Gear or Gearing.

Dish—An annular recess. When the center line of the hub of a wheel is not in the same plane as the rim the wheel is said to be dished. See Artillery Wheel under Wheels.

Dished Wheel—A dished steering wheel is one in which the rim is above the boss, so that the arms incline upward toward the rim. See Dishing below.

Dishing—A wheel is made stronger against side pressures by dishing, that is, arranging that the spokes shall form a cone between the rim and the hub so that the center line of the rim is not in the same plane as the center of the hub.

From dishing there results that wheels are sometimes erected with their spokes vertical and the plane of their rims out of the vertical. See Wheels.

Dishpan Clutch—A form of clutch in which the engaging surface somewhat resembles a dishpan. See Clutch.

Disk, Disc—A flat circular plate of metal, fiber, etc.

This term is used to describe the flywheels in the motorcycle type of engine—the crank pin joining the two. These disks are heavier on one side than the other in order to coun-

terbalance the weight of the piston and connecting rod. In the case of multiple cylinder engines the term has been loosely applied to the sections of metal on the crank webs used to counterbalance the piston and connecting rod, the flywheel being carried on an extension of the shaft, outside the crank case. Fiber disks are sometimes used on the steering wheels to operate the throttle and ignition advance.

A very common form of disk in motor construction is that used in disk clutches, the disks by friction between themselves transmitting the drive. See Clutch.

Disk Armature—A form of dynamo-armature consisting of thin flat coils mounted on the periphery of a thin disk, which revolves with its plane at right angles to the lines of force of the magnetic field.

Disk Brake—A brake which acts by friction on a disk. See Brakes.

Disk Clutch—See under Clutch. A form of clutch in which a disk on one shaft has an annular plunge which enters a corresponding recess in the other disk.

Disk Coupling—A kind of permanent shaft coupling consisting of two disks keyed on the connected ends of the two shafts. In one of the disks are recesses into which corresponding projections on the other are received and thus the two disks become locked together.

Disk Crank—A disk carrying a crank-pin and substituted for a crank.

Disk Piston—A piston so short that it resembles a disk.

Disk-valve—A valve consisting of a perforated disk rotating on a circular seat the openings in which form ports for the admission of steam, etc.

Disk-wheel—A wheel consisting of two disks fastened together at the circumference. Also a worm-wheel having a spiral thread on the face of the disk which drives a spur-gear the space of one tooth at each revolution.

Displacement—In mechanics, the difference, expressed geometrically, between the primary position of a body and its

position at a given time. In a machine having a piston, as a motor cylinder, the measure of space acted through during each piston-stroke.

Also the quantity of water displaced by a body floating at rest. The weight of the water displaced is equal to that of the displacing body.

Distance—The interval or space between two objects.

Distance or Radius Rod—Any rod used to keep the same relative distance between two or more parts, no matter what position they take up.

Radius rods are often fitted between the rear axle and some part of the frame, so as to keep the centers of the chain sprockets at a constant distance apart, and incidentally to adjust the chain tension; also fitted to gear-driven cars.

Distance Block or Washer—A block or washer inserted between two objects to keep them a certain distance apart.

Distance Piece—Same as Distance Block.

Distributer—An apparatus for conveying an electric current to various points in rotation. When a double or quadruple coil is used for a multi-cylindered motor, the current is directed into each coil alternately to fire each cylinder in its turn.

The term is now, however, generally used in connection with the method of arranging the high tension system where two or more cylinders have to be fired, in which, instead of using a trembler coil to each cylinder, one coil supplies the high tension current to all cylinders. In this arrangement one wiper or contact maker is used, which makes contact as many times in each of its revolutions as there are cylinders to be fired. It thus sends a current through the primary winding of the coil, and induces a current in the secondary or high tension winding. It will be understood that this high tension current is sent through the coil every time a cylinder is required to be fired. It is necessary, therefore, to arrange for the high tension current to be distributed to the different cylinders.

The appliance used for the purpose is very similar to the contact maker. The high tension current from the coil is taken to a revolving drum, which rotates at half the speed of the engine shaft. The drum is provided with an arm or wiper, which makes contact during its rotation with as many contact pieces as there are plugs to be fired, so that, while the contact maker is passing the primary current through the coil, the distributer is sending the high tension current on to each plug in turn. See Contact Maker and Ignition.

By this arrangement the timing of the several cylinders is synchronized more perfectly than could be done with a separate coil to each cylinder, and the whole ignition system is simplified. It must be understood, however, that with this system great care in insulating the distributer and the several high tension wires which run from it is necessary. It is also necessary to bear in mind that the distributer—which is generally placed on the dashboard—must be attached to the motor by some positive drive, as it is necessary that its revolutions should exactly coincide with the positions of the pistons in their cylinders, and it should generally run at half speed of the engine crank shaft. Some trouble was originally experienced with these high tension distributers owing to the wipers, which were generally of some yellow metal, causing a metallic film over the wipe surfaces. This has been remedied in some cases by causing the wiper, if we may so call it in such a case, not to actually touch the metallic segments in the insulated ring, but so that the high tension current jumps across when the wiper comes near the segment. This prevents leakage along a metallic film, which would be likely to occur where the wipers or wiper are actually in contact. The jumping of the current across the distributer acts similarly to the jump spark gap. See Intensifier.

Distributer, Eisemann—See under Eisemann High-Tension Magneto.

Distribution—The operation by which steam is admitted into and withdrawn from a cylinder at each stroke of the piston. A similar operation in gas engines.

Distribution-shaft—This is also called the half-time shaft, two-to-one shaft and camshaft in gas engines.

Dividers—A pair of small adjustable compasses used for dividing lines, marking off distances, etc.

Doctors' Vehicles—To the doctor with a largely extended practice, the motor car will eventually become a necessity, if it has not already done so. Its advantages are:

1. It is always ready for an emergency and is available day or night without the assistance of a man.

2. It saves time, and time is money. There is no delay about starting, and when once under way its pace is from two to three times greater than that of the horsedrawn vehicle, according to the traffic and the power of the motor.

3. Distance is immaterial. There is no need for a change of horses, or making provision for resting the horses.

4. The car can be left unattended, whereas horses must be attended, and there is always the risk of their catching cold during long waits.

5. It is economical. It is not necessary to tabulate exactly at what stage the motor car becomes less expensive than the horse-drawn vehicle; it depends on the amount of work to be done. But apart from the actual annual outlay, the enormous saving of time must be taken into account. Also, a doctor who possesses a motor car and can reach his destination in a shorter time than a fellow-practitioner, is more likely to be called.

6. It affords complete rest and recreation. Horse driving is tiring after a certain period; the motor car never tires one. The driving is most fascinating, and the rapid motion through the air acts like a tonic.

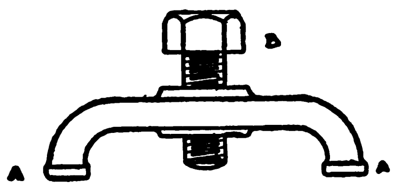
As regards the style of the car to be used, this is a personal matter and depends on the extent of the practice and the amount the practitioner can afford. As a rule, it is more economical in the end to get a really high-class two seated car of moderate horse power. If the doctor still keeps a horse, one car will be sufficient. If he gives up his horses it is well to have a second car in reserve, of larger seating capacity and

higher horse power, which can also be used as a pleasure vehicle. The two seater is, however, most convenient for everyday use, and is very much the most economical. See Choice of Car, Economy of Motoring.

One motor car will easily do the work of several horses, and will not require as much attention as would a single horse and the vehicle used therewith.

Dog—A technical term for a casting or forging having two or more arms bent into a horseshoe or other suitable shape. The end of each arm is provided with a projection, and at the center from which the arms radiate a screwed hole fitted with a bolt is made.

When used to hold the cap on a chamber or two portions of a vessel together, projections are formed on one piece with



DOG.
A, Facings for dog. B, Set screw which holds the dog into position, by being screwed down into a hole midway between A, A.

which the projections on the arms engage, the tightening of the bolt drawing the two pieces closely together. Or the dog may have its arms quite flat, each end bearing on the part to be held in place, with a bolt at its center, the tightening or slacking of this bolt fixing or loosening all parts at once.

Dogs are used in motors to keep the caps covering the exhaust valves in place, and for holding together the pump in some machines. In this connection it is sometimes called a yoke. The form of dog used in a dog clutch for actuating change speed gears is illustrated herewith.

Dogcart—A one-horse cart with two transverse seats placed back to back.

Dog-clutch—See Clutch and Dog, above.

Dome—A name applied in some motors to the part covering the inlet valve. The set bolt through the top of the dome holds down the elbow of the inlet pipe on to the inlet valve, and makes a gastight joint. The inlet pipe is secured to the elbow by a nut.

Dome Light—See under Lamps.

Dominion—The correct political designation of the Canadian federation of provinces—the Dominion of Canada.

Don'ts—The following "Don'ts" should be heeded by all owners and operators of gasolene engines:

Don't tear your engine to pieces if it will not run. The trouble will, in all probability, be located by one of the following tests:

Turn your engine over and see if the compression is correct.

See if you have a spark.

See that the gasolene supply is correct and has no water in it.

See that the needle valve of carbureter is not clogged with dirt.

See that the engine valves are not stuck and that they seat quickly. They should be reground once every year.

1. Don't fail to read instructions on Starting the Engine.
2. Don't forget to keep cylinder lubricator filled and feeding. A dry piston will greatly reduce the power and cut the cylinder or piston.
3. Don't think that the cylinder should be perfectly cold. A gasolene engine works best when it is warm.
4. Don't keep the cylinder too hot or too cold. See that the air has full circulation. It is as necessary as gasolene. An engine can not pull a load if overheated.
5. Don't forget to throw switch out when engine is not in use.
6. Don't forget to shut off gasolene when not running.
7. Don't try to make any improvements on your engine without notifying the makers first.
8. Don't fail to use the kind of cylinder oil recommended

by the maker. It may be better than the more expensive grades.

9. Don't try to wipe engine while in motion.

10. Don't use too much gasolene. The engine develops the most power when working on a smokeless mixture. A black smoke coming from exhaust means too much gasolene; a blue smoke means too much lubricating oil.

11. Don't try to start engine with cylinder full of gasolene. Shut off same and turn engine over a few times before trying again.

12. Don't fail to see that everything is ready before trying to start engine.

13. Don't forget that nine times out of ten when the engine will not run you are at fault. Look around you and see what you have forgotten. It does no good to turn over the engine if conditions are not right.

14. Don't fail to look your engine over carefully when it is in first-class condition. You will then know how to fix it when something goes wrong.

15. Don't fail to have a fine gauze screen put in your funnel and strain all gasolene put in the tank.

16. Don't allow the working parts of engine to knock or hammer. Pay special attention to the connecting rod and keep it as tight as will allow engine to turn easily and run cool.

17. Don't think your engine will not wear out and that it does not need some care.

18. Don't be afraid to try and fix your own engine. You can not tell what a good job you can do until you have tried.

19. Don't allow dirt or dust to accumulate on top of your batteries, as there is danger of short-circuiting them.

20. Don't forget to see that the wires are tight on the batteries and that they may become exhausted in five or six months.

21. Don't run electric bells with engine battery and don't let your engine stand outdoors without some cover for protection from rain. If the batteries become wet they will be short circuited and become useless.

22. Don't forget to look into the gasolene tank before sending for an expert. This seems simple but it has been omitted many times at great expense.

23. Don't forget "Don't" number seven.

The engine will never stop from other than one of the following causes:

24. Gasolene supply exhausted.

25. Air circulation not sufficient.

26. Overload.

27. Gasolene pipe obstructed or the connections loose.

28. Battery failing or broken wire.

29. Spark being set out of time or a short circuit in the insulation of the spring.

30. Not enough oil, or poor oil on piston.

31. Bearings not lubricated and sticking.

32. Intake or exhaust stem sticking or leaking valves.

33. Packing blowing out.

34. Exhaust spring becoming weak or some part becoming disconnected or broken.

35. The gasolene pipe being clogged or having a loose joint.

36. The spark plug becoming short-circuited.

37. Parts can only become disconnected by neglect to keep them tightened properly.

38. Breakages can only occur by some obstruction coming in contact with moving parts, some objects striking engine; or, some part getting loose or disconnected.

39. The screw of the spark coil sticking to the spring. Smooth off the points.

The engine will not run unsteadily from other than the following causes:

40. Lack of oil on all governor bearings, especially collar.

41. Governor out of adjustment by someone changing it, or natural wear.

42. By the catch plate on the end of governor lever becoming worn, so it will not hold up the push lever during the idle strokes of the engine.

43. By the governor lever becoming out of adjustment so

its catch plate can't engage the projection on the push lever when it has been pushed out by the cam.

44. Gasolene valve not properly regulated.

45. Obstruction of gasolene pipe by water or otherwise.

46. If using battery, the battery becoming weak and missing fire.

47. The spark plug points fouled with oil, soot or rust. The exhaust spring becoming weak.

48. The exhaust or intake valve stem sticking slightly, but not enough to stop engine.

49. The accumulation of dirt and grit in any of the governor bearings.

50. The insulation of the insulated spark plug spring becoming short circuited.

51. The exhaust or intake valve leaking.

A Few "Knox" Don'ts.

Below are a few Don'ts urged by the manufacturers upon the attention of all purchasers of "Knox" cars.

Don't start the motor until certain that the spark and throttle control levers are in their proper position (spark lever at highest point on sector; throttle advanced one-quarter way; gear shift lever in neutral position on inside of speed gears).

Don't let the clutch drop in; let in gradually.

Don't start car on other than first speed.

Don't start car with brakes applied.

Don't let engine race or run at a high speed when car is standing idle.

Don't let car stand with gear shift in other than neutral position.

Don't let car stand on hill without applying emergency brake.

Don't advance throttle too far when starting car.

Don't try to run without oil, water or gasolene.

Don't drive fast around corners; it is dangerous and destructive to tires.

"Don'ts" for Drivers.

The following "Don'ts" by Mr. Dave H. Morris, former president of the Automobile Club of America and member of the Committee on Public Safety are also well worth heeding:

1. Don't disobey the rules of the road.—Remember to keep to the right and pass on the left.

2. Don't forget that pedestrians have the same rights as vehicles at street crossings.—Remember that vehicles do not have the right of way at street crossings.

3. Don't forget that your rate of speed should never exceed the legal rate, whatever it may be.—Remember, when local conditions require, to adopt even a lower rate of speed than the legal rate.

4. Don't get "rattled."—Remember that it is the "other fellow" who always loses his head in a crisis.

5. Don't insist upon your rights.—Remember that the "other fellow" may not know your rights, and an insistance on your part is bound to result in an accident.

6. Don't argue with trolley-cars, express-wagons, brewery-trucks, or other heavy bodies found in the public thoroughfare.—Remember that the drivers of these powerful vehicles generally operate on the theory that might is right.

7. Don't expect women and children to get out of your way.—Remember that many women and children don't know how to avoid danger.

8. Don't run any unnecessary risks.—Remember that while the automobile is flexible, powerful, and easily operated, you may make a slip.

9. Don't drink.—Remember that nine-tenths of the accidents occur to automobiles driven by intoxicated chauffeurs.

10. Don't sneak away in case of an accident.—Remember that the true gentleman chauffeur, although he may not be responsible for the misfortune, stands his ground.

11. Don't fail to be a gentleman under any provocation.—Remember that the Golden Rule practised on the road will save you no end of trouble, expense, and worry.

Doors—See Carriage Work.

Dope—Any preparation of a thick liquid or pasty character; any greasy compound used as a lubricant, as axle-grease; any absorbent material, such as cotton-waste, used to hold lubricants, etc.

A term of very wide application in recent colloquial use and found extremely useful by persons of limited vocabulary.

Dos-a-dos—Back to back; said of automobile seats when so placed, or of a car body with seats so arranged.

Double-acting—In mechanics, acting or exerting power in two directions; producing a two fold result.

A double-acting steam-engine is the ordinary form of engine, the steam acting upon both sides of the piston.

A double-acting pump is one which both inducts and discharges liquid at each stroke. It has an inlet and an outlet valve at each end.

Double-acting Brake—A brake that is effective for restraining the backward as well as the forward movement of a car.

Double-acting Pump—See Double-acting above.

Double-chain Drive—The method of motor-car transmission in which two side chains are used. See Transmission.

Double-cylinder Engine—An engine having two cylinders acting in combination with each other.

Double-Threaded Screws—See Screws.

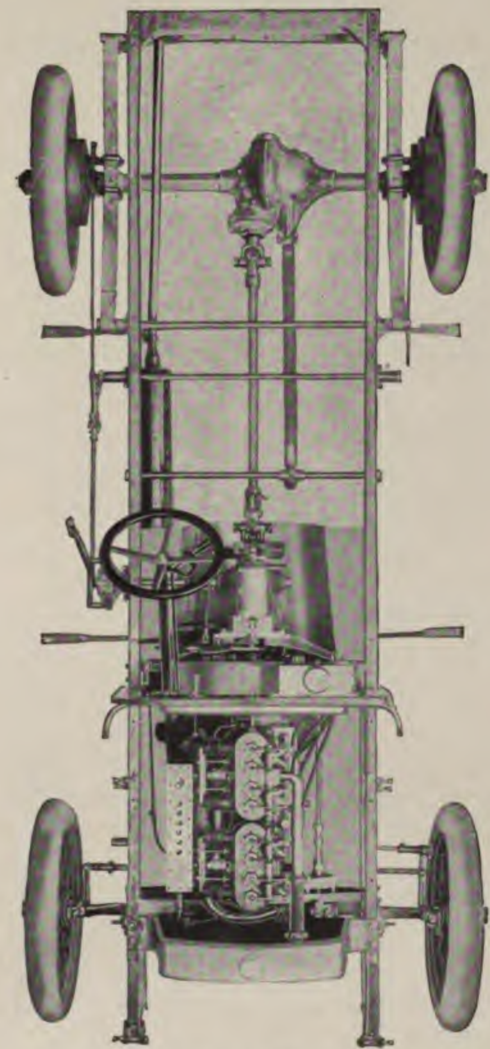
Double-tube Tires—See under Tires.

Dovetail—A joint used chiefly in woodwork. It consists of a number of inverse angular slots, A, in the one part, and a number of similar projections, B, on the other part. The projections fit into the recesses and complete a firm joint.

Dowel—A pin or projection A, fitted on to one part D, which engages with a suitable hole B, in another part C. This insures the two parts being placed in their exact position when assembled. Sometimes called a steady pin.

Draft—The depth of water necessary to float a ship or boat.

A confined current of air; the drawing or moving of air.



The Dorris Chassis—Model C, 30 H.P.

Also, the quantity or the current of air which passes through a furnace in a given time. Forced draft is a draft in a flue produced by artificial means, as by a blower.

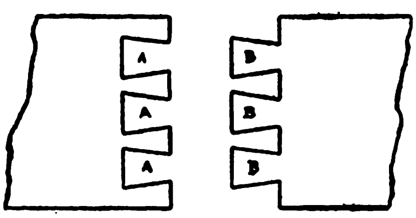
Drag—In foundry work, the bottom part or section of a molding-box.

An attachment for retarding the rotation of a wheel; a skid.

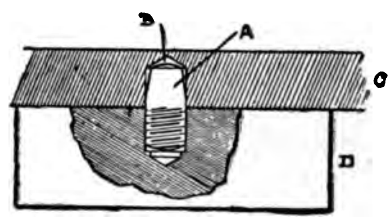
Drag-link—In marine engines a link connecting the crank of the main shaft with that of the inner paddle shaft.

In motor cars, the link connecting the steering arms on the front axle. Also part of a link-motion or reversing gear.

Drain-cock—A cock used to draw off gasolene, water, oil, or other liquids from a tank, chamber, or pipes. One is generally found in the crank chamber of the motor to enable waste oil to be drawn off. Others are placed in the lowest point in the water circulation system, usually in the tank or radiator, in the gasolene tank, and sometimes at the bottom of the carbureter.



DOVETAIL.
A, Inverse angular slots. B, Projections which fit into A.



DOWEL PIN.
A, Dowel. B, Socket for dowel. C, D, two pieces of metal fixed in position in relation to one another by two or more dowel pins.

Drain-holes in Tonneau Floor—See under Carriage Work.

Draining Carbureter—It is not necessary to drain the carbureter before every start, but after a car has rested for any great length of time it is advisable to drain off the water by means of the cock fitted for the purpose.

Draining the Water System—Every water-circulating system should be provided with means for draining off every

drop of water. Some systems have been so efficient that they have been frozen up during a run in cold weather. But the trouble usually consists in cracked jackets and leaking radiators, owing to the freezing of water negligently left in them when the car is put to bed. And neither a cracked cylinder nor a leaky honeycomb radiator is an easy thing to repair.

Draw—To stretch or extend, as in drawing wire; to drag or haul.

The lengthening of an iron rod in forging.

Drawback—Money paid back; a certain amount of customs duties remitted to an importer on subsequent exportation of the goods imported.

Draw-filing—A method of using a fine-cut file by taking it in both hands and, holding it at a right angle across the piece, drawing it backward and forward along the surface, using a gentle pressure. See Files and Tools.

Draw-plate—A plate of hardened steel or of ruby, having a gradation of conical holes through which wires are drawn to be elongated or reduced in diameter.

Dress—An automobilist's dress is entirely a matter of taste, providing a few leading lines be followed. To be appropriate it must be very warm, very windproof, and not wind-catching; its color must not show dust or oil stains, and it must not be so rigid as to hamper his movements.

A driver who starts out with the intention of being his own mechanic and expecting trouble on the road, which may lead to his getting under the car, should carry overalls and put them on before starting to work on the machine.

Every one does not know that a set of overalls made of khaki is an exceedingly presentable-looking garment which washes fairly well.

The reason for putting on the overalls before starting to work is that when the repair is required one never admits from the outset that "this is going to be a long and dirty job," and the preliminary attempts to make shift may result in the

ruin of a suit of clothes before the necessity for the overall protection is mentally admitted.

Drift—A piece of steel of rectangular section, used to place between a hammer and a key which is to be knocked out of position; also a workshop tool of long dimension, and with a cross section of any suitable shape. It has teeth cut upon its edges, and when driven into a hole of approximately its own shape, but slightly smaller, it cuts out the sides and leaves the hole the same shape as its section. The operation is called drifting.

The term drift is also applied to a slow movement of a galvanometer needle, due to fluctuations in the torsional elasticity of the suspending fiber, etc.; also to the difference between the size of a bolt and the hole intended to receive it.

Drill—A pointed instrument used for boring holes, particularly in metals and other hard substances; a boring tool that cuts its way as it revolves; a drilling-machine or drill-press.

Drilling—A kind of coarse linen or cotton cloth. The act of boring holes by means of a drill.

Drill, Pin—A drill having a cylindrical pin projecting from the center of its cutting face. Used to enlarge holes, etc.

Drill, Twist—A drill having spiral grooves around its body for throwing out chips.

Drip Feed—In some forms of lubrication the oil is fed from a sight-feed lubricator, and drips down drop by drop through a glass tube, the frequency of the drops being ascertained by inspection, while adjustable needle valves allow the rate of the dripping of the oil to be regulated. Such a method of feeding oil to the parts requiring it is known as a "drip feed." See Lubrication.

Drive, Direct—See Direct Drive and Change Speed Gear.

Driven Shaft—The secondary shaft in a change speed gear is the driven shaft, the primary being the driving shaft.

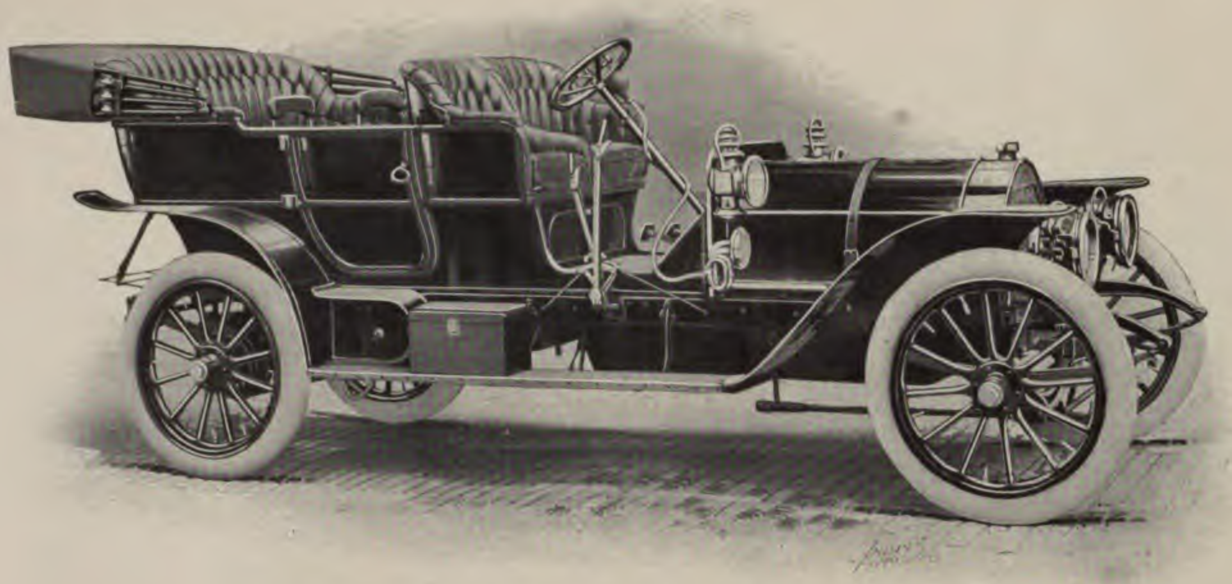
Driver—In machinery, the main wheel, by which motion is communicated to a train of wheels; a driving-wheel.

Driving—The act or art of operating a motor car.

The best way to learn to drive a car is a question that must be decided by individual circumstances. It is generally agreed, however, though not regarded as essential, that the novice should begin with a small light car, if convenient, and acquire confidence in the use of such a machine before undertaking the management of the heavier, costlier and more complex cars. This does not necessarily imply that the man who has never driven an automobile must needs first buy a light car before indulging the desire of his heart to own a powerful, commodious touring machine. Facilities for learning to drive on a small car abound in our cities and towns nowadays, and automobile agents are usually ready to put prospective customers in the way of receiving preliminary instruction on light machines at expert hands. For his own comfort and safety's sake, as well as for considerations of public safety, no man should attempt to drive a car of any size until he has informed himself pretty fully on its details of construction and methods of control. A careful reading and study of the articles in this work on the mechanical features of automobiles (see Motor Cars, Internal Combustion Engine, Ignition, Change Speed Gear, etc.) will give any novice the information he requires for a practical understanding of that branch of the subject, and in the pages which follow we treat of all the problems of driving which are likely to arise in actual experience.

It should be clearly understood that some of the general instructions under this head of "Driving," as well as many of the hints and "tips" which follow, have been written to apply especially to cars of moderate power, such as novices are usually recommended to learn upon. It must be remembered also that thousands of cars made in earlier years of the automobile industry are still in daily use and are constantly changing ownership, so that the mechanism, driving and control of such cars properly receive due consideration in these pages.

At the same time the vast majority of the instructions ap-



1909 Apperson Model K Touring Car—50 H. P.—Seven Passenger.

ply to the driving of any car irrespective of size, though each individual make has its peculiarities which cannot be covered under a general heading.

"Drive slowly until fully competent" is a general instruction to beginners which is all-important and should never be neglected.

Nerve, judgment, experience, and consideration for the public are all necessary for good driving. The mere steering of the car on a dry road where there is no traffic is as simple as child's play, but it is when difficulties arise suddenly that the qualities above enumerated become necessary.

Before Starting.

Before starting a car for the day, first examine the gasolene, lubricating oil and water tanks, and grease cups to make sure they are fully charged. See that the engine and other vital parts are lubricated properly. Make a cursory examination of the wires, batteries, etc., to determine if all the connections are tight. Make sure, too, that the gear lever is in the neutral notch, and that the hand-brake is on hard. Make a general inspection of the car so far as time permits. Then turn on the gasolene, switch on the current, and retard the sparking so as to prevent the risk of back fire. It sometimes happens that the engine will not start freely with the ignition retarded to the fullest. In such a case the lever should be advanced very slightly until the best position has been found by experiment, bearing in mind always that the further it is advanced the greater will be the risk of a back fire.

The carburation lever, when such is fitted, is the next that requires attention. Seeing that the piston can only be made to travel at a comparatively slow rate when operated by the starting handle, it is necessary to put the carburation lever in such a position that nearly the entire volume of air passes round the spraying nipple. Most carbureters nowadays are automatic, so that the correct proportion of air and gas are approximately assured at every revolution. It may, however, be necessary to slightly alter the adjustment of the air supply.

The throttle lever should then be placed in the position which has been found by experiment to be the best one for starting purposes.

Starting the Engine.

The next operation is to start the engine. First operate the small plunger fitted over the float chamber of the carbureter for the purpose of insuring an adequate supply of gasolene vapor, which otherwise might not be sufficient, owing to the impossibility of operating the engine at a fast speed by hand, and the consequent feeble suction. It is best, however, not to "flood" the carbureter in the ordinary acceptance of the term, for if there is an over supply of gasolene the mixture may prove so rich that the engine will not start. It is only necessary to get the mixture rich enough to be easily ignited. Experience will show to what extent the carbureter need be "tickled" to insure the best starting results.

Next, with the handle at the lowest point, grasp it in the right hand with the fingers pointing in the direction in which the handle revolves, and, with the left hand, grip the adjacent dumb-iron so as to give a good purchase. Then standing well clear of the handle give a short, sharp pull upward, more in the nature of a jerk than an ordinary pull, and drop the handle the moment it gets to the highest point.

Should the engine not start after several trials "tickle" the carbureter again and try once more. If the engine still proves refractory, squirt a little kerosene or gasolene—the latter is the most efficacious— through the compression cocks. If this fails, examine the ignition system, especially the plugs. Note that the handle should always be pulled upward, never pushed downward, and it is advisable to place the thumb on the same side of the handle as to the fingers, in case of a back fire. Some motorists adopt the practice of winding the handle until the engine starts. It is a dangerous practice however, for, should a back fire occur, a sprained or broken wrist may result.

Most two, four and six cylinder, as well as some of the later types of one-cylinder cars are provided with a compression release arrangement to facilitate starting. This is actuated

by a rod projecting through the frame under the bonnet in front of the car. It is held in position by a stop while the handle is being turned. When the motor starts, return the rod to its normal position. See Self-Starters.

Multi-cylinder engines, while still hot, can, as a rule, be started by switching on the current, and also when cold, but in this case the driver should give the starting handle a turn or two first, with the ignition switched off, so as to draw in a charge. In the case of one or two cylinder engines it is also advisable to draw in a charge before the ignition is switched on, and the operator should make sure that the piston is on the compression stroke before finally attempting to get the engine in motion.

Advancing the Spark.

Having started the engine the ignition should be very slightly advanced to prevent overheating At the same time the throttle lever should be operated until the engine is running as slowly as possible. The driver should then take his seat in the car, depress the clutch pedal, take the hand brake out of operation, move the gear lever into the low speed notch, open the throttle to a medium position, and let the clutch in as smoothly and gradually as possible. The practice of starting on any gear but the low one, except on a down grade, is not to be recommended, as it strains the engine and entire transmission system.

How to Change Speeds.

It is absolutely essential that the beginner should carefully cultivate the art of changing his gears correctly if he desires to become an expert driver and to drive economically. The sliding type of change speed gear which is now almost universal is, from a mechanical point of view, a somewhat brutal system, because, if the driver is not skilful and careful, he is bound to bring the edges of the gear wheels on the primary and secondary shaft into fierce contact while they are revolving at different speeds. This will cause great wear and may even chip off portions of the teeth. The act of chang-

ing properly is simply a knack, requiring some experience and a quick, delicate and sympathetic touch. The beginner should, if possible, learn this on a small car.

Before making his initial attempt he should endeavor to grasp the difficulties of the situation The problem is as follows: There are two trains of gear wheels (see Change Speed Gear) revolving at varying speeds according to the ratio between the two gear wheels which happen to be in mesh. The change is effected by taking these gear wheels out of mesh, and causing two other gear wheels to mesh whose ratios to each other are not the same as the previous pair, and which consequently are revolving at different speeds at the moment immediately preceding the change. To effect a clean change, therefore, it is essential that at the moment when the two gear wheels are moved into contact they are revolving at approximately their respective "in-mesh" speeds. Otherwise the faces of the teeth will grind against each other.

Different makes of cars generally vary slightly as regards the movements necessary for perfect changing, and consequently we shall describe the best methods for certain types of cars well known in the United States and Europe. This will prove sufficient guide as to general principles. Taking the Peugeot car as a typical example, we will describe the best methods for manipulating the gears. Having started the engine, its speed should be reduced to a minimum prior to declutching, so as to insure that the clutch shaft ceases to revolve. The gear lever should then be moved gently into the low speed notch. If there is any difficulty in getting the gear teeth to engage without grating, the clutch should be let into operation for a moment, and another attempt made, or failing that, the driver should get into the reverse and then immediately go right forward into the low speed. For the second speed the engine should be run at its normal speed, and the clutch taken out sharply and decisively. The change also should be made with decision, the vital point being that both movements should synchronize. At the same time the movement should not be violent.

On the third and fourth speeds, the change should also be decisive, the gear lever being pushed rapidly forward at the moment of declutching. Any hesitation will cause the car to lose impetus, and consequently the engine will not take up its load well, while in many cases the teeth will grind. As regards the top speed, it is direct in the case of the cars manufactured by the Peugeot firm, and is obtained by means of dog clutches. If the action of changing is decisive there is very little risk of missing this gear, but if the operator does miss, the only plan is to go right back on to the third speed, let the clutch in for a moment, and then make another attempt at changing. When changing from a low to a higher speed, it is not well to let the clutch in instantaneously, especially on an up-grade, as the strain will then be considerable, and the speed taken off the engine. There should be just a suspicion of slip to enable the drive to be taken up smoothly. The driver should not change too soon to a higher gear on an ascent. He should wait until he is sure that the engine will take the higher gear without laboring.

In changing down the method is somewhat different. The operator should be careful that the speed at which the car is traveling approximates to that to which he is about to descend, and consequently if he is changing on the level, for the sake of traffic or such like, he should slow down the car by means of the throttle or by taking the clutch out momentarily. In the latter case it facilitates changing to let the clutch into operation again for a fraction of a second before effecting the change. As regards the actual change, whether on the level or on an ascent, the method of declutching is different from that adopted when changing up. Instead of the clutch being taken out firmly, rapidly, and decisively, the foot action should be more in the nature of a tap, only just sufficient to relieve the pressure of the pinions on each other, so as to facilitate their coming out of mesh in response to the pressure of the gear lever, actuated at the same time. The change speed lever should not be operated quite so decisively, but at the same time without hesitation, the object aimed at being to bring

the pinions into contact at the exact moment when the primary gear shaft has slowed to such an extent that the smaller pinion, which is about to be brought into mesh, is revolving approximately at the same rate as the larger pinion on the secondary gear shaft. In getting from the fourth to the third, and the third to the second, it is very unusual to miss changing, but in getting from the second to the first or lowest speed, the smallness of the pinion on the primary shaft, and the likelihood of the car traveling too fast for the low speed, make a change more difficult. The operator should, therefore, wait until the pace has dropped, and if the gears grate should give two or three rapid taps to the clutch pedal, at the same time applying gentle pressure to the change-speed lever, when the gear will easily go home. The engine should not be raced just before the change is made, neither should it be throttled down but should be run at about its normal speed. Should, however, the driver wish to pick up quickly on an ascent he will find it advantageous, just as the gears mesh, to race the engine, at the same time not slamming the clutch in, but letting it slip slightly for the first few yards.

In the light Rover, a typical British machine, the gears, which consist of three forward and a reverse, have to be operated in a somewhat different manner. In changing from the first to the second the action should be comparatively steady, and the clutch taken out sharply. In changing from the second to the high speed the action should be very rapid and sharp, both as regards the clutch and the gear lever. In changing down, the greatest difficulty is getting cleanly from the third to the second. It is essential that the speed of the car should have dropped sufficiently; in fact, a better change can be effected if the speed is allowed to drop below the pace of the second speed. The lever should be operated comparatively slowly, the driver feeling his way, and operating the clutch pedal with a series of little taps should the pinions not slip into mesh smoothly. No attempt should be made to force the gear should the pinions grind, but the driver should continue tapping the clutch pedal and pressing gently on the lever.

In fact, after a touch or two to the clutch pedal to allow the gear wheels in engagement to come out of mesh easily the change can often be effected while the clutch is actually in operation. This applies to some other cars also, more especially when a driver wants to change from a high speed to a lower one when running light on the level—in traffic, for example—or down hill.

In the case of the English Rover it is not difficult to get into the low speed, and the operation is somewhat the same as already described.

In the Argyll car, manufactured in Glasgow, Scotland, there are three speeds forward and a reverse, and it is an easy car to effect a clean change with, due to the special system adopted. In the case of the second and third speeds the gear wheels are always in mesh, and the change is effected by dog clutches. The low speed is, however, operated by sliding pinions. The most important feature of the design, from a gear changing point of view, is that the operating gear is spring controlled. The driver, therefore, cannot force either the gear-wheel faces or the dog-clutch faces into contact with each other. All he can do is to bring them into position, so to speak, and the spring pressure slips them into engagement when the right moment arrives.

In the type fitted to the lighter De Dion cars the pinions are always in mesh, and expanding clutches effect the change. In the Winton type, also, the wheels are in mesh, and the gear changing is effected by bringing friction cone clutches into operation, as described under Change Speed Gear. In both these types it is advisable to make the change gradually, so as to allow the clutch to slip slightly at first and thus take up the drive smoothly.

In the epicyclic type, as fitted to the English Lanchester and the early Duryea, Oldsmobile, and other American cars, the gear wheels are also in mesh, and the application of band brakes, which must be gradually applied, effects the change.

Generally speaking, changes "up" should be sharp and quick to prevent any loss of momentum in the car, while

changes "down" should be effected more slowly, just allowing the gears, under slight hand pressure, to slip in of their own accord when the engine speed has increased to the necessary extent. There should then be no noise.

Use of the Clutch.

The condition of the clutch is all important. If it is fierce it is impossible to take up the drive gradually, and great strain is caused to the engine, gear, transmission system and tires. The care of the clutch is dealt with under a special heading in Repairs and Adjustments and elsewhere under this heading. In starting, the clutch should be brought into operation so gradually that the car moves off without the slightest jerk. In gear changing, the clutch action should be sympathetic and should synchronize with the gear-changing effort. There should be no undue hesitation in letting the clutch into operation again, but at the same time this should be effected so that there is no jerk in taking up the drive. In changing up, especially, this is important. If the change is very rapid when changing down, the clutch can as a rule be let right home, for the pace of the car will not have dropped below the speed represented by the gear on to which the driver has dropped. If, however, the driver is unskilful and changes slowly, or if the gears are badly designed or constructed and do not therefore change at once, it is essential that the clutch should be let slip slightly so as to take up the drive gradually, otherwise there will be an injurious jerk. On the other hand, if the clutch is slipped too much the car may continue to slow down—in extreme cases to such an extent that the engine will not be able to take the gear without laboring unduly—which may necessitate dropping on to a still lower gear. Also, if the clutch is withdrawn in traffic, so that the pace slows, it should be let in again very gradually. Or if the car is running free downhill, and has attained a greater pace than corresponds with the speed of the particular gear which happens to be in mesh, the same precaution should be observed.

Clutch slipping, of course, causes a certain amount of wear

on the clutch faces, and consequently should not be unduly resorted to, as when checking the pace in traffic or nursing the car over the crest of a hill in order to avoid the necessity of changing gear. Generally speaking, it is better to change under such circumstances. Properly constructed plate or disk clutches, working in oil, can be slipped to a greater extent without undue wear than cone or expanding clutches. In fact, in the case of some plate-clutches drivers report that they have found it possible by slipping the clutch to run at such a crawling pace on the high gear as would otherwise be impossible without causing the engine to labor, and nevertheless, after a whole season's use, the wear was hardly appreciable.

The Control Levers.

The power of the engine is affected by the control levers, and consequently excessive movement of the same, unless carrid out gradually, will vary the power of the engine so rapidly as to cause undue strain on engine, transmission system, and tires, just as in the case of a fierce clutch let into engagement suddenly. In the case of some carbureters such sudden and excessive movement will absolutely upset the carburation, and consequently may affect the power temporarily to such an extent that the driver who thus advances his ignition and carburation levers to the utmost, with the object of getting the maximum of power, may get an exactly opposite result—in extreme cases to such an extent that it may be necessary to change on to a lower speed to allow the engine to pick up again. Such conditions are sometimes accompanied by popping in the carbureter. Of course, some automatic carbureters are proof against such inconsiderate treatment, but there are very few which are not influenced more or less.

In some cases the governor is designed to control the ignition, carburation, and throttle, or any two of them in synchronism, with the object of making the control as nearly proof as possible against misuse.

Taking it for granted, however, that there are control levers

for the driver to operate, we shall now give a few detailed hints as to their manipulation.

The ignition lever should never be fully retarded, except when starting the engine. The reason is simple. Under such circumstances the combustion of the gas takes place so late that much of the power is lost, and it is still in an ignited and partly consumed condition when the exhaust valve opens, with the result that the engine is excessively heated. On the other hand, the ignition should never be advanced to the full unless the engine is running at its highest speed. It will, therefore, be seen that a medium position is the best for general purposes, whether the throttle is fully opened or not, and should only be altered when the speed of the engine is approaching its maximum or minimum. When the engine is running idle, the lever might be midway between the medium and the fully retarded position, and when it is running faster, but not accelerated, it might be between the medium and the fully advanced position.

Briefly, the driver should bear in mind that to get the best results he should use the best possible mixture and explode it at the best possible time, that is, just as the piston is about to descend on its down stroke. He must also bear in mind that combustion is not instantaneous, and that the more the mixture errs from theoretically correct proportions the slower is the combustion, so that in such cases it may be necessary to advance the ignition somewhat further than if the mixture is perfect. The same result follows if the spark is very feeble through the battery running out, short circuits, or some such cause. He must also bear in mind, that in the case of high tension ignition—whether by coil and battery or by magneto —there is a distinct "lag" in the coil, which slightly delays the period of combustion, whereas with low tension magneto ignition there is no lag. There is one other point too in connection with the latter ignition. The spark is rather of the nature of a flame than a spark, so that the combustion is more instantaneous. Therefore, the range of effective movement of the ignition lever is reduced. This peculiarity is so pronounced

that some firms make no provision for varying the timing of the spark except for starting purposes. This subject is more fully dealt with under Ignition, Timing, and Repairs and Adjustments.

The carburation lever, where such is fitted, controls the quality of the gas, and the operator should seek by experiment to insure the best possible mixture under all conditions, always bearing in mind that it is better to err on the side of too much air than too much gas, because an over-rich mixture not only prevents the engine from giving its full power, as in the case of an over-weak mixture, but has the additional disadvantage that it fouls the plugs, combustion chamber, etc., and causes overheating, in addition to a most pungent smell.

As a rule the throttle control is connected up to the governor, and a throttle lever on the steering wheel restrains the action of the governor, so that the driver can by its manipulation make the engine run at any speed between the minimum and the maximum. In other cars an accelerator lever or pedal is fitted, by means of which the driver can cut the governor out of action altogether, and the engine will then, practically speaking, race. In this case the throttle lever is used, through the medium of the governor, to vary the speed and consequently the power of the engine within the normal and minimum speeds, the ignition lever being operated in sympathy.

The accelerator lever or pedal should only be used to race the engine under exceptional circumstances, that is to say, when the very highest speed of the car is desired, or when the driver wishes to rush a hill. Many automobilists possessed by the speed craze habitually race their engines, thus causing excessive wear and tear. It is a great mistake, and results in infinite trouble later on.

As already mentioned, the throttle lever should be operated gradually, whether it is desired to increase or diminish the speed of the engine. Sometimes, but rarely, an entirely independent throttle lever is used to control the speed of the engine, and it also should be moved gradually.

Use of Engine Control Levers.

The speed and power of the engine are controlled by means of hand and foot levers, as follows:

Ignition—On steering wheel.

Throttle—On steering wheel.

Governor—For cutting out the governor at any desired point.

Carburation—Generally on dashboard; used for varying the mixture, but now seldom fitted owing to the popularity of automatic carbureters. As a rule, it is not connected with any other control. In the Talbot, however, the extra air inlet is inter-connected with the ignition lever, so that on advancing the spark, as when the engine is running fast, extra air is admitted.

The Accelerator Pedal may act as follows:

(1) On the throttle direct, so that, although the throttle lever on the steering wheel is set at a partially open position of the throttle, the depression of the accelerator pedal will open it fully without altering the position of the lever, and when the pedal is released the throttle will return to the position decided by the position of the lever on the wheel.

(2) On the ignition, so that normally the engine runs with the ignition partially retarded, but when the accelerator pedal is depressed the ignition is advanced. In this case the accelerator pedal is generally coupled up to the throttle as well as to the ignition, and there is no ignition lever on the steering wheel.

(3) On the governor (when such is fitted), which is set normally to keep the engine from running above a predetermined speed. In this case the accelerator pedal is aranged to hold the governor up against the action of centrifugal force, and on being put in action allows the engine to attain a higher speed than that to which the governor would otherwise have restrained it.

(4) In combination with a hand lever on the steering wheel, which will control the point at which the governor will not allow any further rise in the speed of the engine, and which

can also be used to control the engine speed should the driver elect not to use the accelerator pedal. At whatever point the lever is left the governor will cut out, but if the accelerator pedal is depressed, it nullifies this action and allows the engine to increase its speed up to the maximum at which it is set to run.

(5) Or it may be coupled both to throttle and ignition as before, so as to advance ignition and open the throttle more fully than they are set by the two hand levers on the steering wheel, and, when released, to return them to the positions fixed by the position of these levers. In this case there is no governor.

(6) It may also be used in connection with the governor which controls the throttle, as in case (3), and at the same time to advance the ignition.

(7) It may also be used in the same way to advance the ignition as well as to put the governor in operation as described in case (4), where a hand lever is used in combination with a governor.

Principles of Gear Changing.

It should be understood that whenever two wheels have to be put into gear with each other, their edges, or periphery, or teeth, whichever term may be used, should be moving at the same speed. This does not mean that the wheels should be rotating at the same speed. Only when both wheels are of the same diameter will this be the case. When they are of different sizes the smaller wheel will rotate faster than the other, though the speed of its teeth—that is, the distance they travel—will necessarily be the same during any given period of time. Any tooth on the small wheel will, of course, travel a complete circle, while a tooth on the bigger wheel will not have completed a circle on account of the larger circumference.

The Peripheral Speed of two unequal wheels in gear with each other remains the same.

The Angular Velocity, or the time taken by the wheel to travel through a certain angle of its circle, varies.

The beginner should first get the following facts into his head:

WHEN CHANGING UP—Neutral to low speed. Primary shaft revolving; secondary shaft idle. Low speed to second; second to third; third to fourth. Primary shaft with its gear wheels running comparatively fast; secondary shaft comparatively slowly. As one goes up the scale the difference in speed of the shafts becomes less.

WHEN CHANGING DOWN—Primary shaft with its gear wheels running comparatively slowly; secondary shaft with its gear wheels comparatively fast. As one descends the scale the difference in speed of the shafts increases. In most cases, when running on the fourth speed, the primary and secondary shafts are revolving at the same rate. The effect is the same, however, as the primary shaft has to be slowed to allow the smaller third speed wheel on it to mesh with the larger third speed wheel on the secondary.

To make a clean change, therefore, when changing up, depress the clutch firmly and rapidly, and operate the lever with deliberation at first, but quicker when changing from second to third and third to fourth.

When changing down, take the clutch out comparatively slowly, so as to allow it to slip, and operate the lever gently and deliberately.

A study of the appended diagrams, Figs. 1, 2, 3, 4, and 5, will make our meaning plainer. A, B, C, and D represent the gear wheels on the primary shaft of a four-speed Panhard type of gear, in which the drive is indirect on all speeds; A1, B1, C1, and D1 represent the gear wheels on the secondary shaft. X represents the primary shaft, on which are mounted the gear wheels A, B, C, and D. This primary shaft, as its name implies, is directly connected with the clutch shaft, and so takes the drive directly from the engine. Y is the secondary shaft, on which are mounted the gear wheels A1, B1, C1, and D1, and from the rear end of which the power is transmitted to the road wheels.

When the gear lever is in the neutral notch, all the gear wheels are out of mesh with each other, and consequently, although the engine revolves the shaft X, the power is not communicated to the shaft Y, which, provided the car is at rest, does not revolve. If, however, the car is running free, the turning of the road wheels will necessarily revolve the secondary shaft Y with its gear wheels.

Neutral to Low Speed—Now, taking it for granted that the car is at rest and the engine running, it is necessary, before the power can be communicated to the road wheels, that one of the gear wheels on the primary shaft X be moved into mesh with one of the gear wheels on the secondary shaft Y. Naturally, the low speed wheels will be the first to be brought into mesh. In other words, in order to start the car,

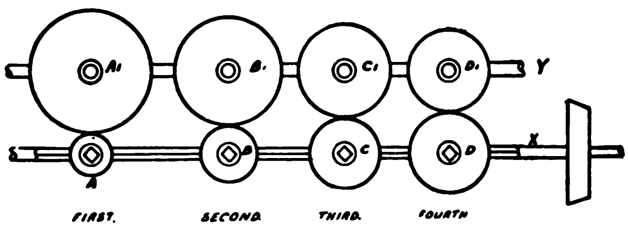


FIG. 1.—THE VARYING DIAMETERS OF THE WHEELS.

the very small wheel or pinion A will be moved into mesh with the very large wheel A1.

Now, the car being at rest, but the engine running, shaft Y (including wheel A1) will be motionless, but shaft X (including pinion A) will be revolving. If an attempt were made to get into the low speed while this condition of affairs existed, the teeth of A would grind against the teeth of A1. Consequently, the operator must take the clutch wholly out of engagement and wait a few moments until it has ceased revolving. Shaft X, and with it pinion A, will then have come to rest, and A and A1 can be brought into engagement with each other without grinding. (See Fig. 2.) Should the teeth come right opposite each other and refuse to engage, replace the gear lever in the neutral notch, let the clutch into engagement for the fraction of a second, and try again.

In getting into the reverse, the same programme should be followed.

It sometimes happens that the clutch shaft will not stop revolving when the clutch pedal is depressed. This is generally due to the clutch leather having swelled, or, in a plate or disk clutch, to the plates or disks sticking together. It may also be due to insufficient lubrication of the spigot bearing. See Clutch, under Repairs and Adjustments.

To change from neutral into the low speed or reverse is, under these circumstances, very difficult. The best plan is to slow the engine as much as possible, then suddenly close the throttle altogether, operate the gear lever, and then reopen the throttle before the engine has stopped revolving. The teeth of the gear wheels will probably grind a little, but

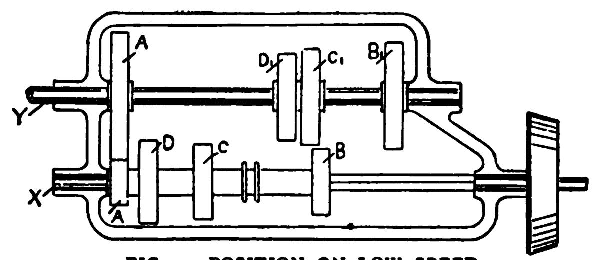


FIG. 2.—POSITION ON LOW SPEED.

A, A1, Low speed wheels. D, D1, Top speed wheels.
B, B1, Second speed wheels. X, Primary Shaft.
C, C1, Third speed wheels. Y, Secondary shaft.

almost at the first touch the primary shaft, which, of course, is moving very slowly, will cease revolving, allowing the teeth to mesh. The condition of the clutch should be attended to at the first opportunity and the defect remedied.

From Low Speed to Second—To change from the low to the second speed, A must be taken out of engagement with A1, and B moved into engagement with B1. It will be noticed, however, that A is very much smaller than A1. Consequently, while A and A1 are in mesh, shaft Y (including wheel A1) will be revolving very much slower than shaft X (including pinion A). It will be also noticed that there is a considerable disparity between the sizes of wheels B and B1

(which must be brought into mesh for the second speed), though the difference is not so great as between A and A1. As already explained, however, it is essential, if a clean change is to be made, that the teeth of B and B1 should be moving approximately at the same speed when they are brought together. In other words, the speed of shaft X has to be reduced. (See Fig. 3.)

To accomplish this, the clutch must be sharply and wholly withdrawn just as A and A1 are taken out of mesh, and the gear lever moved gently into the second speed notch, so that there will be an appreciable interval in making the change, just sufficient and no more, to allow the shaft X, which is then disconnected from the clutch shaft, to slow down, so

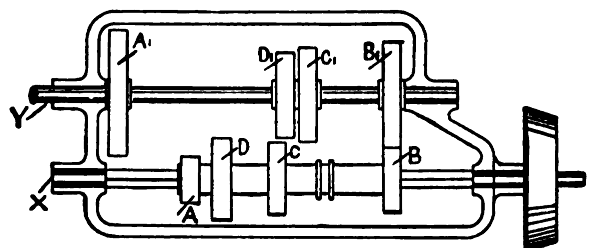


FIG. 3.—POSITION ON SECOND SPEED.

that the teeth of the two wheels are traveling at the same speed.

There are other factors, however, which complicate the movement, and render great judgment and experience necessary to effect an absolutely clean change. For example, if the car is running on the level when the clutch is withdrawn, the pace will not drop appreciably in the brief interval of time necessary for changing, and, consequently, the road wheels will continue to drive shaft Y at almost the same number of revolutions per minute as it was revolving before A and A1 were taken out of mesh. Under such circumstances, the actual movement of the gear lever forward need not take more time than about one second, if as much, the period depending to some extent on the weight of the clutch, and also the position of the throttle, for if it is comparatively open the engine will

race when the load is taken off it, and, therefore, as the clutch comes out, it will start revolving faster. If, however, the car is running up a slight grade when the change is being made, it will lose speed more rapidly, and, consequently, it may require a slightly longer interval—a small fraction of a second longer, probably—to allow shaft X to slow down sufficiently to permit of B meshing cleanly with B1. Of course, if too long an interval is allowed, the car will have slowed down so much before the change is effected that the engine will not be able to pick up the higher gear.

On the other hand, if the car is running down-hill when the change is being made, it will increase in speed when the clutch is withdrawn, thus causing Y to revolve more rapidly

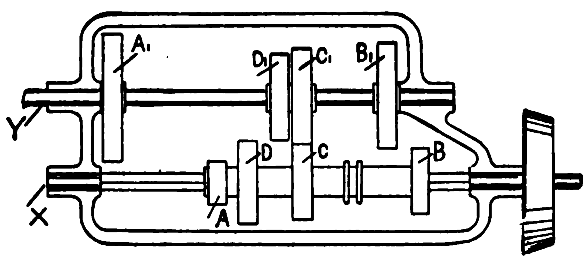


FIG. 4.—POSITION ON THIRD SPEED.

than before, and necessitating a less gradual change. The delay in moving the lever is in all cases, however, very slight. In fact, there need be no actual stop, but rather a gradual steady push forward. If the movement is too slow, the speed of shaft X will drop too much relatively to that of shaft Y, and the teeth of B and B1 will grind. It will then be necessary to let the clutch into engagement again for a fraction of a second so as to speed shaft X up a little, and to then continue the operation of pushing the change speed lever into the second speed notch.

Second to Third—In changing from second speed to third, the same procedure will have to be followed, but as we go up the scale the movement should be less gradual owing to the disparity in size between the primary and secondary gear

wheels C and C1 (Fig. 4) being less, and consequently the difference in the speed of revolution of shafts X and Y will also be less.

Third to Fourth—In changing from the third to fourth speed, it is generally unnecessary to make any pause whatever, but to manipulate the lever with a quick, decisive motion, for in this case shaft X is not revolving much faster than shaft Y at the moment that C and C1 are taken out of mesh, and wheels D and D1 are of equal size. (See Fig. 5.)

If there is considerable friction between the male and female portions of the clutch so that it takes an appreciable time for the male portion to come wholly out of engagement, the slowing down of shaft X will take longer than otherwise.

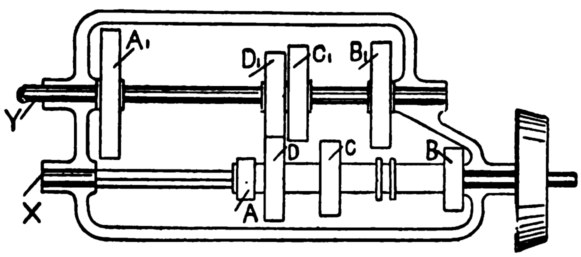


FIG. 5.—POSITION ON TOP SPEED.

If, however, there is a clutch stop fitted, shaft X will slow down very rapidly indeed, and the movement of the lever when changing up should be rapid.

Should the driver miss gear when changing up, he had better let the clutch into engagement for the fraction of a second, return to the gear he was on before, and then try again.

Changing Down—When changing down, the condition existing as to the relative speeds of shafts X and Y renders necessary a reversal of the operations. Starting with the fourth speed, it will be seen in the diagram that the gear wheels D and D1 are the same size. Sometimes D is bigger than D1—generally when a direct third speed is fitted. If D and D1 are the same size, shafts X and Y will revolve at the same speed, but if D is the bigger, X will revolve slower

than Y. The third speed wheel C1 will, of course, be revolving at the same speed as D1. C, however, being a smaller wheel, will have to rotate quicker than C1, to insure the teeth meshing, and consequently the shaft X will have to be quickened so as to enable these two wheels to mesh easily. The same applies to B and B1 and A and A1; but as the disparity in size is greater as lower speed gears are reached, the shaft X will have to be speeded up proportionately.

This speeding up of shaft X is accomplished by slipping the clutch—that is, by not taking it wholly out of engagement as when changing up, but by allowing the male portion to remain slightly in contact with the female. What is necessary is that the clutch should be so far withdrawn as to ease the pressure of the teeth against each other, so that the gears may be moved out of mesh. As soon as they come out of mesh, the clutch, still having a certain hold of the shaft, which is now free from the driving strain, rotates the latter at an accelerated speed owing to the engine automatically accelerating when the load is taken off.

The amount of slipping necessary can only be found by experience and experiment. As the different stages between high and low are reached, the disparity between the size of the gear wheels increases and, consequently, shaft Y has to be increasingly accelerated.

When changing into the reverse, the driver should be very careful not to attempt to make the change until the road wheels have come to rest. It is wise also to keep the clutch out, before making the change, sufficiently long to insure the primary shaft coming to rest.

We have dealt with the Panhard system because it is more simple to explain with it what is necessary in gear changing. In other gears, as in the case of the Mercedes type, in which a direct drive is obtained, and in which the power is transmitted to a countershaft and back to an extension of the primary shaft, exactly the same conditions obtain, and exactly the same methods of changing must be adopted.

If the countershaft in this case is regarded as the primary,

which it practically is, it will be seen that it is in reality a Panhard type. In such cases, however, the direct top gear is easier to get into owing to it being accomplished by engaging some form of dog clutch instead of sliding wheels into mesh sideways.

So far we have dealt with general principles. There are other factors to be taken into consideration, however, such as the speed of the engine at the moment of changing and the variations in different designs. We shall deal with the engine speed first.

The Engine Speed as a Factor.

It will be easily understood that, if the engine is driving with the throttle open, or nearily open, as the clutch is withdrawn, the engine will race as the load has been taken off. Hence, there will be a brief period, at the moment when the male portion of the clutch is just coming out of engagement with the female, when the acceleration of the latter will cause a considerable increase in the revolution speed of the male portion, and, as the male portion drives the shaft X, there will also be an increase of speed in the shaft X. This increase of speed will, needless to say, further increase the difficulty of making a clean change.

The exception to this is in the case of those gears which have a direct third speed and an indirect fourth speed; or where the secondary shaft is idle on the direct gear. In the former the car is geared up on the top speed, and, therefore, the operation of gear changing will be modified accordingly. In the latter case, changing gear from top to next gear will be rendered easier.

To obviate this difficulty, it is a common practice to take the foot off the accelerator, or operate the throttle lever, as the case may be, at the moment that the clutch is withdrawn, thus preventing the engine from racing when the load is taken off it. The moment the change of gear has been effected, it is necessary for the driver to push down the accelerator pedal again or operate the throttle lever without a moment's delay.

In some cases the clutch pedal is connected up to the throttle, and partly closes it when the clutch is withdrawn. On the level or down hill the closing of the throttle, and consequent slowing of the engine, works admirably; but on an up-grade it tends to reduce the power of the engine so much at a critical period that, unless the change is made very quickly and the throttle opened again with the least possible delay, the engine either picks up very slowly or else fails to pick up at all, so that when changing up on an ascent it may become necessary to drop back to the lower gear, or, when changing down, to drop a stage farther on to a still lower gear.

It is when changing up that the difficulty is greatest. As already explained, it is necessary that shaft X should be slowed, and that as quickly as possible, for every moment that elapses while the clutch is out the car is losing its momentum and slowing down. This slows down shaft Y, which was already traveling much slower than shaft X; consequently it adds still further to the difference between the speed of the two shafts. In other words, if shaft X accelerates abnormally at the moment the clutch is being withdrawn, it means a longer wait to allow it to slow, and during this longer wait Y is also steadily slowing down through the car losing its momentum. Hence, when the change is at last effected, the car has slowed so much that the engine may not be able to take up the drive, and one has to drop back again to the lower gear.

Also, there is another disadvantage. If the clutch is let in gradually when the engine is racing furiously, extreme friction will be generated which may burn the clutch leather. If it is let in suddenly, the strain on the engine and transmission systems will be enormous.

It will be seen, therefore, that there must not be undue delay when changing up on a hill, and that the engine must not be allowed to race furiously while the clutch is out.

The best practice is, immediately before changing, to throttle down to a point which would give in or about normal engine speed with the load off. Then change as rapidly as is possible without grinding the gear wheels, and just as the

clutch is being let in again (but before it has fully engaged), open the throttle. The engine will then be accelerating again just as the male portion of the clutch is coming into frictional contact with the female, and unless the grade is too close to the limit of the gear it will pick up steadily, even when the full load comes on.

When changing down on an up-grade the difficulty is not so great. To insure a clean change, we want to increase the speed of shaft X as compared with shaft Y. The falling off in the momentum and speed of the car will assist towards this end by reducing the speed of Y. Consequently the engine can be run faster during the change when changing down than when changing up, especially if the clutch is only slipped slightly during the change; but, of course, the engine, and with it X, must not be accelerated too much. The change, as a rule, can be made fairly rapidly, and as the engine is running at a reasonably fast speed, it will pick up well.

On the level or down-hill the engine should always be throttled off, as under such circumstances there is no difficulty in picking up. The operator should be careful that the speed at which the car is traveling approximates to that to which he is about to descend, and, consequently, if he is changing on the level, for the sake of traffic or such like, he should first slow down the car by means of the throttle, or by taking the clutch out momentarily. In the latter case it facilitates changing to let the clutch into operation again for a fraction of a second, and declutch again slowly before effecting the change.

There is another system of changing down on a descent which works most satisfactorily, but requires some learning. With the throttle almost closed, take the clutch out of engagement, move the gears in operation out of mesh, but then pause with the gear lever between the two gears; next let the clutch in for a moment so as to speed up primary shaft X, declutch and change slowly into the lower gear. Under such circumstances, the car is likely to be traveling too fast for the lower gear, and, consequently, the clutch should be let into engagement very slowly or the car speed will be checked

with a suddenness that will strain both engine and transmission.

The Use of the Brakes.

Nothing is more detrimental to a car than the improper and excessive use of the brakes. The driver should bear in mind that, no matter what system is adopted of checking speed—with the exception of the forces of gravity or inertia—a strain is brought to bear on the transmission system and tires, and that this strain becomes excessive and exceedingly detrimental if the car is checked or stopped with great suddenness. In most cases the engine itself forms a fairly efficient brake, and acts more smoothly and more gradually than is possible for any mechanical brake. For this reason it is less likely to cause side-slip. The best way, therefore, to stop a car is to gradually close the throttle, and the driver should begin to do so in ample time, so that the retarding influence may be as gentle and gradual as possible. To get the maximum stopping effect it is generally necessary to switch off the ignition, because very few throttles are so perfect in action that a certain amount of explosive mixture does not find its way through. In descending steep hills, however, the strain to the engine is considerable where this method of braking is solely employed, and consequently the rear wheel brakes should be used to assist the engine, for which purpose it is, of course, necessary that they should be disconnected from the clutch.

Some types of engine are so designed that the engine practically becomes an air compressor, and affords an exceedingly powerful and reliable form of brake. The pedal-regulated camshaft which attains this end should be gradually operated, and on steep hills the hind wheel brakes should be used to assist the engine.

As regards the hand and foot-applied brakes, all are agreed that one should be disconnected from the engine, and many experts consider that this should be done in the case of both. Of course under such circumstances it is very necessary to declutch by means of the clutch pedal when the car is being brought to an absolute standstill. These hand and foot-applied

brakes should invariably be applied gradually, except in the case of a sudden and serious emergency. For general application, as in traffic for example, the foot-applied brake is the most convenient, but it causes the greatest amount of strain, owing to the braking effort being taken up through the transmission system. For this reason the rear wheel brakes should be used on all steep down-grades in preference to the countershaft brake, and great care should be observed to see that the compensating mechanism is in order, so that the retarding influence on one wheel is not greater than on the other.

The driver should train himself in the constant application of the hand brake, and he cannot do this better than by using the hand brake exclusively, say for a week at a time, so that he may instinctively be able to use this brake quickly in case of an emergency, instead of having to fumble clumsily for the lever. Needless to say, it is essential for safety that all brakes should be kept in perfect order, and it is a wise precaution to test them within the first few minutes after starting. There is no more hopeless position than to unexpectedly find one's brakes out of order when called upon to make a sudden stop.

Tapping in the Engine.

Sometimes it will be noticed that the engine, which has been running perfectly well and easily, will begin to make a slight tapping sound. It is not sufficiently pronounced to be called a knock, and very often it will puzzle the driver to know what it is caused by, and in the majority of cases he will be apt to put it down to some slight peculiarity of his valves. As a matter of fact, it is nothing of the kind, but is due to very slight premature ignition which is easily remedied. See Ignition.

One Cause of Irregular Firing.

If one's engine is heard to knock very violently, so much so that the first impression given is that either the crank-shaft has broken or the big end bearing bolts have got adrift, it is well before jumping at such a conclusion to carefully examine the ignition. In one such case which occurred at the end of a

short tour, the engine started knocking so badly that the owner of the car feared to run it any further, and left it some thirty miles from home, wiring the makers that something had gone seriously wrong with the engine. It was ultimately discovered that the contact blade of the commutator was fractured and that the knock was due entirely to irregular firing caused thereby.

Want of Gasolene: Its Symptoms.

It is often a simple thing which causes an involuntary stop. This was brought home to a writer on the automobile press very forcibly on one occasion. The particular small car he was driving had the gasolene tank beneath the seat, and the supply to the carbureter was shut off by means of a needle valve. Through frequent use the thread of this valve had become sufficiently worn to enable the road vibrations to shake it round, and thus reduce the supply of gasolene. In the first place, he could not account for the extraordinary loss of power in the engine. Power rapidly decreased, and then firing back through the air inlet of the carbureter began to give additional trouble. When this stage was reached he considered it quite time to investigate matters. The first cause to which he attributed the trouble was bad inlet valves. These were examined, and found to be working quite correctly. He then tried starting the engine up, and it went at first turn, but very quickly repeated the previous performance, and back-fired through the carbureter. The next move was to examine the carbureter to see whether it was getting sufficient of the necessary fluid. It was found that the supply valve was very nearly closed, thus allowing only half the needful quantity of gasolene to pass to the carbureter.

Effect of Plunging Cars on the Carbureter.

When light, very easily sprung cars are driven with but one or two passengers on the front seat—the plunging of the cars over rough roads will be found to affect the gasolene feed to the float chamber of the carbureter. The plunging will cause the float to jump and flood or shut off the feed, so that for a

few moments the engine is starved of gas. Next to weight on the back part of the car, this involuntary cutting out of the engine, when gasolene is fed by gravity, may be largely prevented by keeping the gasolene tank full. The head of gasolene appears considerably to check the undesirable action of the float when the car is plunging on bad roads.

To Avoid Sideslip Downhill.

Most owners have had experience of driving on frozen roads, and the novice will find, or has already found, that extreme precaution is necessary when descending winding hills. There is one practically safe method of descending without danger, and this applies, of course, to slippery roads of any kind in cities. It consists of driving with the wheels at one side in the gutter. If one wheel is already in the gutter, there is very little tendency for the car to slip out of it. Again, if the car is close to the sidewalk, a slip of an inch or two into the curbstone is not much to worry about. As long as one stays in the gutter it is impossible for the car to turn round and go broadside down the hill. Further, in many cases roads are only frozen on the crown, and at the side and in the gutter there is pretty good holding.

Luck and the Tire Bill.

Undoubtedly a very large item in the cost of running one's own car is that due to the upkeep of the pneumatic tires. This item varies very largely with different drivers of cars, and a low bill for tires is usually attributed to luck. Now, luck plays a very inconsiderable part in this respect; really and truly, one might say no part at all other than that of missing broken glass, horseshoe nails, etc. The most serious damage which is done to tires is that due to excessive speed, overloading, sudden letting in of the clutch, misuse of the brakes, and driving over newly paved roads with the full power of the engine operating at the road wheels. All of these are practically solely and entirely due to bad driving, and have nothing to do with inherent bad properties of the tire. With the flexible throttle control, as fitted to modern cars, the necessity of

constantly applying brakes vanishes, and if only reasonable care is exercised by a driver, almost the whole of the running can be done on the throttle; hence the brake need only be used on very severe hills and for pulling up at any place. Some clutches are much fiercer in action than others, but the knack of gently letting in the clutch can be acquired if intelligently practiced, so that no snatch is transmitted from the engine to the road wheels. The sudden action of any clutch or brake simply causes lumps to be ripped from the tread of a tire when on a rough road and thus the life is very considerably reduced.

Another point is overloading the tire. The buyer of a car should insist upon having tires with an ample margin for the weight carried. The first cost may be a few dollars higher, but in the long run this is saved over and over again.

It should always be remembered that wet surfaces cut rubber much more readily than dry. In the case of small cuts on the tread these should at once be filled with one of the special tire repair preparations, to prevent them opening out or being further cut. If these remarks are properly digested, the tire bill will be considerably lessened apart from so-called luck.

Driving over Loose Stones.

A careful driver becomes much exercised as to how he may do his tires the least possible amount of harm when passing over a newly-laid patch of stones. The more general method is to drop down on to the bottom speed and go over as gently as may be, yet this oftentimes results in the tires being badly cut. Now, if when approaching a patch of loose stones the car is allowed to run right up to it at speed, and the clutch is taken out before the front wheels strike the stones, the vehicle will have sufficient momentum to carry it over most ordinary patches of new laid pavement at a minimum risk to the tires. If the momentum is insufficient to carry the car past the stones, nothing remains but to drop to the low speed and go on gently. On no account should the clutch be let in so that momentum may be maintained as immediately the engine begins to drive when the gear ratio speed is above that of the

speed of the vehicle the very worst cutting action is put on the tires.

Driving Home on the Rim.

It must occasionally fall to the lot of every automobilist to find himself obliged to drive home on the rim—in other words, he is unable to keep any air in his tire, he is without spare tires or too short of time to struggle with a refractory inner tube, and so elects to drive on, and ignore the consequences. Common prudence will suggest a moderate speed, and if the distance to be traversed be short, the security bolts well tightened, and the road surface smooth, it is possible that little harm may be done. Supposing the cover to be badly burst, while the tube is in good condition bar the burst, it is a good plan to remove it and drive on the cover alone—its last drive most likely. If both cover and tube are in good order, and the deflation is due to a puncture or loose patch, it is well to screw the bolts up for all they are worth, and if the cause of puncture is to be found in the shape of a nail or piece of glass, remove it. When putting things right in the privacy of your garage you will doubtless find the leather heads of the security bolts badly crumpled; if they will straighten out so much the better, if not they can be made good with canvas. A most important point is to see that they are not bent out of shape as regards the plates which form the heads. These are in the form of a flat bottomed V, and the sides are very liable to spread under such treatment as suggested. If they are put back in such condition they fail to bed down into the rim, and in consequence the inner tube will be able to blow down under them, and give way at inconvenient times. Not that any time is convenient for tire trouble, but some times are less inconvenient than others.

Gear Missing in Speed Changes.

If, when changing speed, the gear misses, depress the clutch pedal again quickly, and the gears will invariably come in at once without causing any jar upon them. When firmly in,

the clutch should be let in gently to pick up the momentum the car has lost.

Engine Thumping at Gear Changes.

Sometimes when a gear change from a lower to a higher speed has been made, it will be found that the engine commences to thump heavily. This is due to the fact that the change has been made a little too soon and before the speed of the car or the resistance warranted it. The thumping can be instantly stopped by lightly touching the clutch pedal, so that a little slip takes place. The engine then quickly picks up, and the thumping ceases.

Epicyclic Gear Changing.

Owners of cars with epicycloidal change speed gearing should be particularly careful to change their gears gently. As a matter of fact, the amateur driver who is used to sliding gear changing is, for a short time, hopelessly at sea on a car with the type of gear mentioned, for whereas with the sliding gear a quick motion is necessary for gear changing, the other type requires a gradual feeling action for the change. Thus, on cars employing epicyclic gears, the driver should be careful to apply the brake which changes the gear as gradually as possible, otherwise the strain on the gear is very considerable, and stripping a by no means distant possibility. Lubrication of the drums is quite permissible, and is usually provided for, but if not, the driver of the car should see that some thin oil is used occasionally to grease the peripheries of the various speed-changing brake drums.

Returning to the Slow Speed Gear.

When one has run up to and come to a rest at a point at which it is desired to stop on top speed, a little difficulty will sometimes be found in returning the change speed lever to the neutral notch in the quadrant. The teeth of the toothed wheels on the sliding sleeve on the clutchshaft do not at the moment exactly coincide with the gaps in the toothed wheels on the gearshaft, and the wheels will not pass each other. Of course,

the clutch can be let in slightly, which would alter their position with regard to each other, but not infrequently the teeth still foul. The depression of the brake pedal, however, and the consequent grip of the brake bands, or blocks, on the brake drum will, permitted by the slight play in the propeller-shaft, cause the gearshaft to move just enough to permit the passage of the wheels on the sliding sleeve through their fellows, and allow the neutral notch to be at once attained.

To Learn Changing Gear.

This can be done in the garage or anywhere private. Block up the rear axle well and solidly, so that the tires are at least two inches from the ground level, and wedge the front wheels at front and back, with substantial wedges or planks. Start up the engine again, and sit at the steering wheel seat; depress the clutch pedal slightly, and gently work the speed lever to try and bring it into the first speed notch. Probably a grating noise will be heard, and you may fail to get the wheels properly in mesh. Let back the lever to its original position and try again. If the lever goes into the notch, then at once let up the clutch pedal gently, and you will notice the rear wheels will at once commence to revolve. Depress the clutch and they will stop; let it in again and they start. Practice this, and afterward try to get in the next speed higher, first by depressing the clutch, and at the same instant bring the speed lever into the next higher notch, and immediately let the clutch in gently without loss of time. The rear wheels will now revolve faster, and you can then try higher speeds; then practice reducing the gear by doing everything in the same order. While on each of the gears, the engine can be run fast or slow with the throttle and spark levers, as before mentioned. The reverse can then be tried exactly in the same manner, most cars having the reverse and forward speeds actuated by means of one lever. In the exceptions to this rule there is no difficulty in following out the operations to be gone through if the levers are carefully examined and their effect noted when they are operated.

Never Look at the Lever Quadrant.

One occasionally comes across car owners of some experience—men, too, who profess to be particularly keen upon mastering the technique of their machines—who have not acquired such rudimentary skill as is involved in changing gears without looking down to see when the lever is alongside a notch in the quadrant. It may be excusable for absolute beginners to do this, but it is an extremely dangerous practice when driving in traffic to take one's eyes from the road in order to look down at the quadrant when changing gears. Particularly at night time should the practice be avoided, so that the dodge of rigging up an electric lamp in a position where it will illuminate the quadrant must be regarded as the invariable sign of the clumsy beginner. Gear should be changed by feeling, not by sight. The only time the quadrant should be looked at is when one has stopped on the top speed. One should then see that the lever has been put in the neutral notch before leaving the car.

Driving on the Brake.

It is very bad practice to drive on the brake, though some people who know no better think it showy. By driving on the brake we mean driving jerkily. For instance, we will assume that the driver is coming to a turn or overtaking a block in the traffic. Instead of reducing his speed gradually as soon as he sees the necessity for a slack or perhaps a stop, he rushes up to the point, and then jams on all his brakes and pulls his car up dead. The next moment, as the necessity for the slack has passed, he crowds on all available power without allowing his engine a moment to recover and introduce itself gradually to its car. This sort of thing ruins any engine and car, as it subjects them to extremely severe shocks and strains. In fact, there is no doubt whatever that more than one mysterious failure has been caused by the parts being overstrained through this reprehensible manner of driving.

Using the Brakes.

The fact that there are two or more brakes to every car seems to have escaped the notice of many drivers, for in

a large proportion of cases the hand brake is used solely as a sort of stand-by. The foot brake is always used, the hand brake rarely, with the result that the first is unduly worn, while the wheel drums are hardly ever called into play. Now, apart from the fact that this is not economy, it is very bad driving policy, in that the driver, never using his hand brake, does not cultivate the instinctive operative faculty, with the result that in cases of urgent need thought is necessary before he can apply his emergency brake. Now, on many of the old pattern cars this was perhaps excusable, for the lever was frequently very awkward to reach and cumbrously unhandy. On the newer cars, however, this has been altered. In many cases, the hand brake lever is pivoted to and swings over a parallel quadrant to that for the change-speed lever, and it is generally in convenient reach of the driver.

The Rational Method of Braking.

Beyond this, many makers have gone a step further, and so arranged that their brake lever pulls back towards the driver, in place of the older push-forward motion. This is the rational action, since, should it be necessary to apply the whole braking power the car possesses, the driver would be pushing with his feet and pulling with his hand, each force exerted transferring its reaction to the other brake, thus rendering the motions both more efficient and more natural. With almost all wheel brakes, compensating devices are fitted, so that the retarding action on each wheel is the same, and all the strain is taken by the hub of the wheel. Where the countershaft brake or brakes or the propeller-shaft brake is used, there is all the slack in the chains or the lash in the teeth to be taken up before the action takes place, or, in other words, there is a reversal of strain from the brake backward. If you want your car to last, use the hand brake for ordinary driving more widely. It is only a question of use. Use is second nature, and the cultivation of the hand brake may save the automobilist a serious accident. In the interests of public safety also every

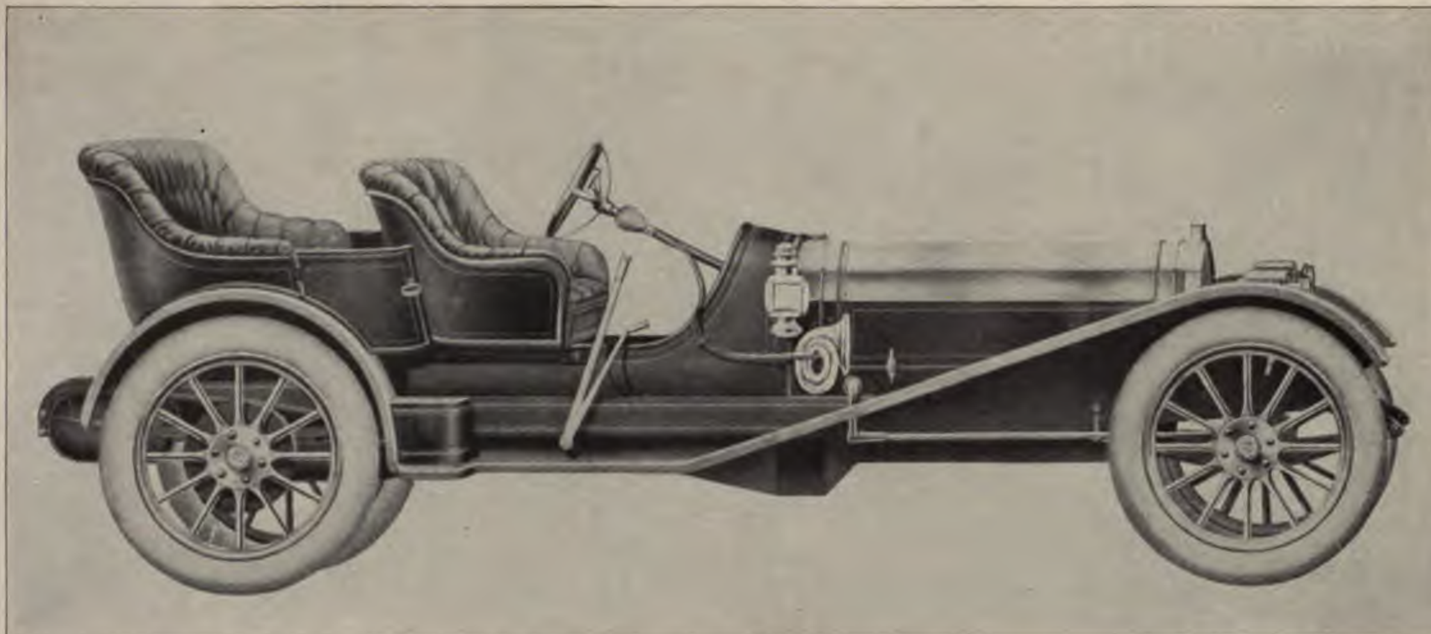
driver should accustom himself to the instant use of all his available braking power.

Driving on Treacherous Roads.

Those who are unfamiliar with the gyrations of a motor car under the influence of sideslip are often at a loss to know what to do when the car begins to slip even in a gentle manner. Now, as a matter of fact, sideslip is one of those things which come upon one suddenly; but if a number of such sideslips are analyzed they will be found to be due to a too harsh application of the brakes, or to the upward changing of the gears, when the conditions are such as not to permit of the road wheels taking up the increased speed applied to them and at the same time getting a firm grip of the road. As a general rule, it will be found, if one drives on one's proper side of the road, that the tendency of the car is to slip towards the off or right-hand side, this being due to the camber of the road, so that the rear wheels of the car have an inclination to slide upon the greasy surface down to the gutter. On some of the narrow and highly cambered roads occasionally met with there is the greatest difficulty experienced in keeping the car straight. The natural inclination is for it to proceed crab fashion rather than in a straight line.

Conduct in Sideslip.

Under such circumstances it is perhaps better to wait until the way is clear, when the car can be put directly across the road and again brought on to the crown, when all will go well so long as the crown of the road is kept to. Under other circumstances, when the car shows an inclination to slip towards the right, if the front wheels are also steered towards the right they have a wholesome checking influence upon the rear wheels, which, once having commenced to slide, prefer to take the front wheels as a pivot whereon to turn, and if the pace or the weight of the car and the general conditions are such as to give sufficient momentum, it is not at all unusual for the car to turn completely round. In such instances the checking influence of the front wheels is not very great, but is



Welch 6-Cylinder 75 H.P., Baby Tonneau, 5-Passenger Car.

frequently sufficient to prevent the car doing any serious damage to itself. If, on the other hand, the wheels are turned outward, they only aggravate the sideslip by causing the driving wheels to push the front of the car more up on to the crown of the road, so giving sufficient momentum at the rear end either to turn the car itself completely round, or possibly to damage the rear wheels or axles seriously by a violent collision with the curb.

Starting under Difficulties.

If an engine will not start on the switch, and the starting handle is lost or so bent through a collision as to be useless, the car may be pushed with the engine in gear, or even jacked up at the back. This plan has been tried occasionally when a back wheel was turned by hand, which, of course, made the engine work. Directly it fires, the speed lever must be put into the neutral position and the jack removed. This operation, however, needs care, particularly when the car has a chain drive.

A few cars are still used with detachable starting handles, and these, like any other articles, can be lost. If the engine will start on the switch, the problem of getting a car under way is easily solved. Another alternative is to put the car in gear and get a person to push the car. If, however, one has no passengers, and there is nobody at hand to give assistance, the difficulty is one which might be thought to be insurmountable.

We give one method suggested for overcoming the difficulty, but which should not be put into practice unless everything else fails.

One rear wheel should be jacked up, and everything set for starting. The jacked-up wheel should now be pulled round in a forward direction, which will rotate the engine. The top gear should be put into engagement, as the engine will then start with less manual effort. Directly the engine is rotated, the speed lever should be put into the neutral gear position, before the jack is removed.

Starting a Motor on Coal Gas.

When attempting to start a gasolene engine "from the cold," instead of injecting gasolene into the cylinders or warming the carbureter with hot cloths, insert one end of a piece of rubber gas tubing in the air intake of carbureter, and connect the other end of tube to the nearest gas bracket. Upon turning on the gas, the engine will be found to go off at the first or second turn of the starting handle, and, unless it be of very large dimensions or the gas supply very attenuated, will continue to run at a moderate speed. Gasolene can now be turned on, the carbureter flooded, and, after a few seconds, the gas turned off, leaving the engine running on gasolene. This method will be found very simple in practice, and saves much exertion at the starting handle. When an engine is missing fire, it can readily be ascertained by running the engine on coal gas as described above, whether the carbureter is at fault or not.

One word of caution: Owing to the strong suction in the air intake, the coal gas is sucked out of the gas main much faster than it would issue by its own pressure, and the result is that any lights in the vicinity will probably be sucked out.

Popping in the Muffler.

Numerous owners who have learned to drive a De Dion car, enquire how to account for explosions in the exhaust-box, and how they can be prevented. One such owner says that the engine must be bewitched, inasmuch as it nearly always pops when passing restive horses. The explanation is simple, and the cure of the phenomenon easy. Popping in the muffler nearly always occurs through the mixture being too weak, so that the charge is not exploded in the cylinder, but passes out through the exhaust-valve into the muffler, where it is ignited by the heat of the exhaust pipe or box. When traveling fast, the mixture lever is adjusted to admit plenty of air to the carbureter; in the De Dion car the mixture lever is pushed toward the steering column, while the timing lever is pushed forward for early sparking: but when the pace is suddenly

checked, as it naturally would be when approaching a restive horse, the mixture is upset because the piston speed is not sufficiently great to suck in a sufficiency of spray to mingle with the air; thus it happens that the very act of suddenly checking the car in order to pass a restive horse slowly has the effect of provoking explosions. The remedy is always to remember to push the mixture lever forward when suddenly checking speed.

Gasolene Leakage: Lamp Dangers.

If a leak in the gasolene tank or connections is discovered at night, the lamps should be put out at once, and care taken that no light is brought near the car. If it is impossible to rectify the leak without light, and no electric lamp or torch is available, the acetylene lamp may be lighted and placed at least four yards from the car. When the leak is stopped, the escaped gasolene should be wiped away, and a few minutes should be spent in waiting for what is left to evaporate before attempting to light the lamps.

Driving with Slack Chains.

"It once fell to our lot to drive a light car having side chain drive," writes an early enthusiast in motoring. "These chains were so loose as to cause some anxiety, for there was every possibility of their leaving the sprockets. This eventually happened, but luckily gave no great trouble in replacement. It was found that the stretcher bars had been lengthened out to their utmost, and, therefore, there was no chance of giving the chains the necessary adjustment; and being well on into the night, it was hardly a pleasant task to start taking a link out of both chains. To prevent further possibility of the chain coming off, we religiously stuck to the second gear for the remainder of our journey—some sixteen or eighteen miles—and drove on the brake when descending hills. The object of this was to keep the chain taut on its top side, with the engine throttled down and the brake just applied sufficiently to retard the car to keep the chain in the desired position, and this prevented all further troubles."

Extemporizing a Valve Spring.

A useful addition to the motorist's outfit is a length of piano wire about the same gauge as the existing inlet spring. It not infrequently happens that a proper valve spring is not included in the spare parts carried, and when one of these becomes weakened or breaks, it is often a matter of difficulty to get even so small a thing into proper working order again. By carrying a piece of wire of this type, a spring of practically any required strength can be made and used without the necessity of tempering, as would be the case with most of the other kinds of wire used for spring making. This may appear to some to be superfluous, but many owners have had experiences in which a length of wire would have meant a great saving of time and temper had it been available.

Hauling a Car.

In the event of a breakdown irremediable upon the road, when recourse must be made to haulage by another car, or anything that can exert tractive force, care should be taken as to the manner in which the tow rope is attached to the car. It is by no means advisable to make the tow rope fast to the front axle; it is better to secure it to the projecting ends of the frame, which serve as spring horns, and pass the rope between these and the ends of the springs themselves. The haulage stress is then distributed evenly through the frame to both axles. The ends of the rope so passed should be taken and attached to any suitable part of the haulage equipment. If the car is to be loaded up on to a dray or wagon, take care that the wheels of the dray are securely blocked before any attempt is made to run the car up the inclined planks by which the floor of the dray is to be gained. Be ready also with suitable blocks or rods to secure the wheels of the car and arrest it at any part of the ascent if this should prove necessary from any cause whatever. Where a car has sustained such damage to one of the front wheels that it cannot travel on it, a strong pole may be passed under the front axle or the frame, and fastened to the back axle. The front end of the pole can

then be attached to the towing vehicle, so that the damaged wheel is raised just off the ground.

Steering with Broken Gear.

Happily, steering gears are not now so prone to give way as they were a few years ago, but should any reader be so unfortunate as to have a distance rod of the steering gear come adrift, the following tip may be of use: Failing any temporary repairs, the car should be turned round by manual aid, and the front wheel which is not connected to the steering wheel should be lashed up to prevent its turning athwart the car. The vehicle may now be driven slowly backward, steering by the one wheel, which now becomes a trailer. This method is, of course, bad for the tire, and should only be resorted to when a repair can be effected within a couple of miles or so.

Economizing Gasolene.

The distance which one driver can accomplish on a given quantity of gasolene is often a subject of much astonishment to the driver of another and similar car, who finds it almost impossible to get the same results out of his own vehicle, although it is, as we have remarked, identical with the one consuming the lower quantity. The whole question lies in the fact that the one who is able to use a lower quantity of gasolene has hit upon the correct method of running his engine—and that is allowing the carbureter to take in as much air as it possibly can, and still to retain a good mixture. The most effective mixture of spirituous vapor and air is that which will run the engine at its highest power, which power is in no way increased by increasing the richness of the mixture. What is really meant by this can easily be ascertained by the owner of any motor in the following manner: Close down the air opening to the carbureter so as to obtain a rich mixture for starting, and then turn the starting handle, when the motor commences to work. Attention should now be turned to the air inlet. Open this slowly, and if a governor is fitted this should previously have been put out of action by the accelerator being pulled up or tied down, as the case may be. As the

mixture assumes its better proportion, the engine will perceptibly quicken its speed, and with its speed the power, of course, increases. Continue opening the air inlet until it is wide open, and if there is no marked diminution in the speed of the engine, it may be assumed that it is running on the best proportion of mixture obtainable. If, on the other hand, the engine begins to slow down, the air inlet should be closed down again until the engine picks up its previous speed and gives out that note which spells power. The engine is now running to its best advantage, and is consuming the smallest amount of gasolene possible. At the same time this is only a rough guide to getting the correct adjustment, as the engine is doing no work. A road trial must be made to see how nearly the garage ideal can be reached. This applies to the vast majority of carbureter adjustments. See Gasolene Economy.

Contributory Causes of Loss of Power.

From time to time one comes across motors of which their owners complain that, while they do very well on the level, they behave scandalously when a hill of any gravity presents itself before them. Making a general and cursory test, it is found that the compression in each cylinder is good, the ignition apparently satisfactory, the timing correct, the operation of the valves visually good—in fact, there seems nothing emphatically responsible for the sluggishness of which the owner complains. Now, there is only one thing to do in such case, and that one comprises many. It is to go carefully and minutely through the motor, and, though it will not be found that any one detail is radically at fault, yet it is more than probable that one or more sparking plugs are dirty or have spark gaps too large, the electrical connections are somewhere loose and dirty, there is a slight short somewhere, there is deposit in the carbureter, or the gauze filters at the bottom of the tank or in the union close to the float feed chamber are more or less choked, an exhaust spring is weak and its valve does not close as smartly as it should, the holes in the muffler are choked with mud or grease and there is some back pressure

caused thereby, one of the brakes is rubbing more or less on its drum, a pneumatic tire is soft, the accumulators are down a bit, or there is a considerable deposit of carbon on the combustion chamber walls and piston heads. These small matters taken separately do not appear to be particularly serious, and should not of themselves detract in any marked degree from the pulling power of the engine. Let us suppose, however, that each of these little failings reduces the horse-power by one-tenth. It will easily be seen that their sum total of reduction is enough, and more than enough, to deprive the engine of that vim without feeling which no true automobilist is truly happy at the wheel.

Substitute for a Governor.

Single-cylinder cars, and, in fact, most of the less expensive ones, are somewhat difficult to drive in traffic. The constant manipulation of the clutch necessitates frequent acceleration or slowing down of the engine. This is generally done by keeping the hand on the advance spark lever, so that when the clutch is taken out this is moved back to slow the engine down on running light. On letting the clutch in again, the spark is advanced to enable the engine to give the required power for driving. For these operations two hands are necessary—one on the steering wheel and one on the sparking lever. If, in addition, it is necessary to change speed rapidly, or to use the hand brakes, either the steering wheel must be let go altogether or the engine must be allowed to race—that is, if it is not fitted with a governor of some kind. This partly applies to speed changing. When changing up, the engine has to be slowed from the moment the clutch is withdrawn until the higher gear and clutch are engaged, when the spark can be advanced. If this is not done, the moment the clutch is depressed as a preliminary to gear changing, the engine races objectionably.

A simple way to overcome the difficulty is to connect the clutch pedal to the contact breaker, so that when the clutch pedal is depressed to withdraw the clutch the sparking is re-

tarded, but allowed to return immediately the clutch is re-engaged. This is done by disconnecting the contact breaker from its advance spark lever, and fitting a spring tending to advance it to its utmost. A wire or rod is then fitted from the contact breaker to the usual control lever, enabling it to be set in any position by pulling it back by means of the hand lever against the action of the spring. This leaves the contact breaker controllable in exactly the same manner as before. From the clutch pedal or some part of the clutch connections a wire is led to the contact breaker in such a way as to pull it back to its most retarded position when the clutch pedal is fully depressed. This can best be done by means of wires, though they are somewhat unreliable; if rods are used, a sliding connection must be made between the clutch rod and hand lever rod to allow the contact breaker to be retarded by the clutch rod without necessitating any movement of the hand lever.

Starting Single-cylinder Engines.

In starting single-cylinder engines, very often trouble is experienced, this apparently being due to the engine being cold or to the carbureter hardly giving a correct mixture. With a De Dion type of engine, this trouble is readily got over by simply leaving the ignition switch off, and then depressing the inlet valve, and at the same time giving about three or four brisk turns to the crankshaft. Then when the switch is placed in the on position and the crankshaft given a brisk jerk so as to bring the piston over the compression point, it will be found that starting is quite easy. Of course, the throttle valve must be opened before the inlet valve is depressed.

How to Get the Best Work Out of a Motor.

Here are three good fundamental rules for getting the best work with the least consumption out of your engine:

1. Drive with ignition advanced to the utmost short of engine knock.

2. Admit as much air to the carbureter as possible short of getting misfires.

This, of course, only obtains with carbureters in which the air supply is controllable.

3. Never let the engine run hot or in want of the proper supply of lubricating oil.

To Start an Engine Easily.

One often hears of motorists, especially novices, who have great difficulty in starting up their engines. They are often afraid to stop their engines while leaving the car for a few minutes, on account of their difficulties on re-starting. In most cases starting is quite easy if care is taken always to close the additonal air inlet and open the throttle fully. If necessary, the carbureter should be flooded slightly. This should be done not by lifting the needle valve, or by holding down the plunger, as in a Longuemare carbureter, but by lifting and depressing it sharply, so as to spray the gasolene from the jet right up the inlet pipe. This coats the walls of the pipe with gasolene, and a firing mixture is taken into the engine at once, no matter how slowly it is turned over. The starting handle should always be turned round sharply through the three easy strokes, so as to insure sufficient suction to take in a proper mixture, and should then be jerked over the compression stroke by an upward pull on the handle. With carbureters of the Longuemare type, in which the inlet is at right angles to the jet, if the carbureter be flooded too much, an excess of gasolene collects in the well at the bottom of the jet, and far too rich a mixture is obtained for starting. For this reason excessive flooding should always be avoided, as it is rarely, if ever, successful in getting the engine under way. A good tip to facilitate starting is to open the throttle wide and close the air inlet just before switching off, so that the cylinders and inlet pipe are filled with a rich mixture, ready for the first spark on turning the engine over. Some drivers always make a point of starting up with the left hand, so that in the event of a back-kick the right hand gets off scot free, though there is no occasion for anybody receiving a bad back-kick. However, it is as well to cultivate the habit of starting up with the

left hand, so that should the driver experience a sprained wrist, he can get along by using the other hand. It will be found easier if on putting the car away for the night the gasolene cock is turned off before the engine is stopped, and the carbureter will then become empty without the trouble of drawing the gasolene off. In very cold weather it will be found helpful to fill up with warm water, thereby warming the engine, which will then start at the first or second turn.

To Prevent Being Dazzled.

It is always advisable to have ready a pair of tinted or smoked glasses or goggles, so as to be prepared for driving against a low sun. In the early morning, and less frequently in the evening, when one is driving facing a low sun, it is quite impossible to see. If a pair of smoked glasses are available, there is no difficulty. Of course, the trouble only occurs when one is driving almost directly against the sun, and without tinted glasses it is quite impossible to proceed with safety either to oneself or to other road users, at anything above a mere crawl. There have been many horse and cycle accidents, some of them fatal, entirely due to the blinding effect of a low sun.

For Stopping Leaks.

Always carry a piece of bread somewhere on your car, says a practical French motorist; rye bread for choice. Rye bread is sometimes difficult of acquisition in this country, so a good wheat bread may suffice. The bread is not to be stored against a prolonged "panne" (see En Panne), and consequent famine in the depth of the wilds, but because under certain circumstances the staff of life can be of much avail in directions other than that of alimentation. A slight leak in a radiator can be most efficiently, although temporarily, staunched by means of paste made from bread kneaded with the fingers. The paste must be well kneaded, then spread over the leaky part, and worked in with some tool which will do duty as a spatula, just in the way painters work up their colors on a palette.

Attention to Tire Valve and Bolt Nuts.

After every run out on a car, the air tube valve nut and also all the securing bolt nuts should be carefully gone over to feel whether they have worked slack. With the running on the road this frequently happens, so that it is a good plan to try all of these with a small pair of pliers, as the thumb and finger grip on these is not sufficient to tighten them up satisfactorily. If the bolt nuts are allowed to get slack, there is a great tendency to shear the bolts or deform their heads. The heads tend also to tip up, and the result is that the inner tube gets nipped beneath the head, and in a very short time bursts, thus causing serious trouble on the road, but the pliers must be used very lightly.

Skidding or Side-slip.

Skidding is one of the most dangerous enemies that the automobilist has to guard against. There would seem to be no law governing side-slip, and at times no amount of skill in driving will entirely prevent it, though the danger may be modified to an extent. Skidding may be divided into two classes:

1. Due to grip of road surface being insufficient to enable driving wheels to propel car. In this case, as the road friction is not likely to be the same under each driving wheel, the differential enables that wheel having the better hold to do more than its share of propelling, with the result that the car is slewed round out of its course. This is the form of skid which is easiest to correct, for it is only necessary to take the clutch out.

2. Due to either change of direction of car or reduction of its speed under conditions when road surface is slimy and treacherous. This class of side-slip has huge possibilities and can only be avoided by driving slowly or, in fact, as if all brakes on the car had been dismantled. Carefully watch the way in which the road happens to dish, especially round corners. Of course with non-skid chains or bands these difficulties mostly vanish, but it must be remembered that a man who has never learnt to drive without such devices becomes

hopelessly lost if he happens to be driving a car having tires with ordinary treads on a slippery road. Apart from bad road surface, skidding is promoted by a faulty differential, back brakes unequally adjusted, frame or axles being out of alignment, or one tire having slightly greater diameter than its fellow.

The class of mud on which a motor car slips is exactly the same as that which affects a bicycle, and consequently the driver who is also a cyclist will be in a better position to judge than one who is not. Briefly, if the mud is thick and half dried, or if there is a thin film of grease over the paving, or if the road surface is composed of a slimy quality of limestone, the driver must exercise great caution. Frozen roads are, as a rule, safe. A sheet of ice, however, must be traversed cautiously, and if the surface has sufficiently thawed to become wet, it will be even more treacherous than the worst class of mud.

The best safeguard against side-slipping is to travel slowly at a steady, uniform pace. A sudden, violent application of the brakes, a sharp turn of the steering wheel or a sudden acceleration of pace may set up slipping. The driver should therefore, try to run his engine at an absolutely uniform speed, and should avoid traveling at a pace which would necessitate a strong application of the brakes should an obstruction suddenly block the road. In fact, when the grease is really bad, he should regulate his speed so that the manipulation of the throttle lever will slow the car sufficiently to provide for the ordinary exigencies of traffic.

The action of a car on a greasy or slippery road is often deceptive. The driver may find he can maintain a fast pace without any sign of side-slip, but he is almost helpless should the need arise for a sudden stop. If he puts the brakes on suddenly, the car may swing right round. A swerve or an attempt to take a corner quickly will also have the same effect.

When a side-slip does occur, the driver should declutch the engine on the moment. If he has applied his brakes, he should let them off again, and should momentarily give the car its head, so as to afford the wheels an opportunity of biting, but

should then instantly turn the steering wheel in the direction necessary to right the car. If the wheel is violently turned in the opposite direction to the slip, the car is most likely to continue slipping, and perhaps will turn completely round. Should the latter happen, the driver must let his clutch in again, at the very moment that the front of the car points directly up or down the road, when the front wheels will probably again grip.

There is practically no time to think in the case of a side-slip. The necessary action is instinctive and practically instantaneous. If the driver does not declutch at once the car will dive into the ditch, and if he does not do the right thing at the right moment with the steering wheel the car will turn round. He will only gain skill by experience, and the only way to avoid accident while gaining the necessary skill is to drive very slowly at first, so that if a slip occurs which he is unable to control no damage will result. It is a good plan to practice side-slipping at a slow pace on a wide, unfrequented road. The control will then come very quickly. A really expert driver is able to actually reverse his direction by a sudden twist of the steering wheel, and yet control the slip so that the car will "fetch up" when it assumes an end-on position in the roadway.

When descending a steep hill the dangers resulting from side-slip are intensified, for the brakes cannot be safely used to any extent, and the car may continue sliding broadside on, or slowly revolving owing to the slope of the hill. On an exceptionally slippery hill, as, for example, when the surface is coated with wet ice, a safe descent may often be effected by driving with the wheels at one side in the gutter. This gives the wheels a bite, and tends to prevent the car swinging broadside on. Also if a slip does occur the proximity of the curb, be it of earth or stone, prevents serious results should the car strike sideways and come to an immediate stop.

It may, perhaps, seem that driving on a greasy road is exceedingly dangerous. To the experienced driver, however, it is not so. He quickly learns the speed at which he can travel

with safety, and the amount to which the brakes can be applied without causing side-slip. Should the car swing round, it will not sustain any damage unless it strikes some obstruction or glides into a ditch.

There are many non-skid devices on the market of more or less efficiency, by the use of which the risk is reduced to a minimum. See Tires.

THE ART OF DRIVING.

Having dealt with the manipulation of the clutch and the various control levers so as to get the best results out of the car, we shall now give some hints on how to become a safe and expert driver. The beginner too often falls into the mistake of thinking that to drive a car well is a very simple matter, and before he has found out his mistake he may have caused injury through faulty manipulation, and perhaps have met with a more or less serious accident. He should take as his motto, *"Festina lente"* (Hasten slowly), and should not conclude that because he can steer straight on a clear road, it is therefore safe to travel fast. Nothing but experience will teach him to act instinctively in an emergency, and until he can so act he is in constant and imminent danger if he attempts to drive fast. He must bear in mind also, that a motor car requires almost as much sympathy as a horse if the best results are to be attained.

His initial practice should be done at a very slow speed, not more than from 10 to 15 miles an hour. He should learn how to slow, to stop, to reverse and to turn, and should practice these various operations until he is perfect. As regards steering, he should not be satisfied until he is able to follow a true course, and if, on descending a steep hill for example, the steering should show a tendency to get out of control and the car to sway, he should not lose his head and jam on his brakes, but should check the car gradually by means of the throttle until he has coaxed it into the way of rectitude once more. Even with drivers who have had some little experience, this danger of a swing from side to side being set up is one that has to be reckoned with.

To slow down gradually, use the throttle; to stop altogether, check the pace by the same means, but when the car has dropped to a speed of a few miles an hour, declutch and apply the hand-brake. To stop in an emergency, declutch and apply both brakes, but only to an extent that is absolutely necessary.

Ascending Hills.

When approaching a hill, it is often well to rush it, if the coast is clear. For this purpose advance the ignition, open the throttle, and temporarily race the engine. The momentum will carry the car up a considerable way. As the engine slows, gradually retard the ignition, and the moment the engine shows any signs of laboring, change on to the next speed. As the engine picks up under the lighter load, the ignition can be slightly advanced again, so as to get the best results out of it. It is a bad practice to *frequently* slip the clutch in order to struggle over the crest of the hill without changing. When climbing on the low speed it is a mistake to race the engine—taking it for granted that the gradient is well within the car's powers. Racing is very severe on the engine under such circumstances, and will cause overheating.

Descending Hills.

In descending hills, both judgment and experience are necessary. If the grade is gentle and the road straight, free from traffic, and without side roads, a fast pace may be maintained. Under no circumstances, however, should a steep hill be descended fast if there are blind turns or if there is much traffic about. On dangerously steep down-grades it is essential to safety to begin the descent slowly. At a fast speed the momentum is enormous, and once the car has got out of control the brakes cannot be relied upon to hold it. Most of the serious accidents recorded have been due to drivers tackling a dangerous hill at too fast a pace and losing control. If the driver, through want of caution, finds himself traveling too fast on a dangerous descent, he should act promptly but with discretion. To jam the brakes on to their fullest may only cause one or both to collapse. Taking it for granted that he

is running against compression (with the ignition switched off), he should apply both brakes with gradually increasing pressure until the speed is checked, and should descend the rest of the hill at a slow speed, relying upon compression and one of the brakes, using these alternately, so that they will not overheat, and keeping the other in reserve. If one brake is connected to the clutch, of course he can only use the other in combination with the engine. At a high speed the engine compression loses a large proportion of its effectiveness, and it may then become necessary for him to apply the second brake, thus declutching. The operation should be done quickly, but with judgment. On a long hill, which is steep, but not necessarily dangerous, it is very unwise to descend at a high speed with the brakes on. The heat generated under such circumstances is enormous, and the brakes at any moment may become ineffective, or even collapse, when, with the high momentum obtained, it would be impossible to stop the car. On long, gentle hills it is advisable to switch off, as this gives the engine a chance of cooling. Very few throttles are absolutely gastight.

When surmounting an exceptionally steep incline, on, say, the low speed, it is well to keep in view the possibility of a shaft breaking or a chain coming off, when probably the only available brakes, namely those on the back wheels, might not prove strong enough if the car commenced to run backward. A good plan is to hug the near side of the road (if not a precipice) so that if such an accident occurred the car should be quickly backed into the curb, fence or gutter. If the road is wide, however, hug the most dangerous side, and then, in case of a stoppage from the above causes, swing right across the road backward. The car will probably come to a standstill before touching the curb or fence.

Driving in Public Streets.

Exhibition driving in the public streets is at least bad style. It should be remembered that there are many people who are unable to judge how quickly your car can stop, and though

it may be distinctly humorous to see an elderly person dancing a fandango in front of a car which has some time previously come to rest, there is no doubt that much needless irritation and dislike for automobiles in general may be thus caused.

If, in traffic driving, a doubt arises as to who should give way, be sure to do so yourself. Doubts of this nature gradually become fewer as a driver's experience and judgment increase.

On Turning Corners.

The art of taking corners without endangering oneself and other road users is worth cultivating. The motorist should make an invariable habit of keeping to his own side of the road at these corners, even though, as when turning to the left, the act of swinging wide will bring him off the crown of the road and necessitate a slower pace. When turning to the right, he should not take the corner at such a speed as will make him swing wide, for if other traffic is advancing to meet him, an accident is very likely to occur. The slower the corner is taken, the less will be the strain on his differential gear and tires. For this reason also it is very advisable to declutch as the car begins to turn, and not let the clutch into engagement again until the corner has been almost negotiated. Another important point should be borne in mind, and that is, that the severe application of the brakes when in the act of turning a corner tends to upset the car, and, if for this reason alone, the corner should not be taken fast.

Passing Side Roads.

Side roads constitute a very serious danger, especially if the fences are so high as to obscure the view. If the automobilist is on the main road he should sound his horn and slow down on approaching the side road. His safest position under such circumstances is in the middle of the road, as it gives him more scope for maneuvering should anything emerge from a side road. At the same time, should an accident occur, his position in the middle of the road might be regarded as contributory negligence.

If the automobilist is emerging from a side road into a main road he should bear in mind that the traffic on the main road has, so to speak, the right of way, and is justified in proceeding at a much faster pace than the traffic emerging from the side road; in fact, the onus, to a great extent, devolves on him to drive so as to cause the least possible risk of collision. If he is about to turn to the right there is little risk, because the traffic advancing to meet him will be either in the middle of the road or to its own right side, and, consequently, will leave him ample room. If, however, he is turning to the left, great caution should be observed, because, in this case, he will have to intercept the line of approaching traffic before he can get on to his proper side of the road. He should, consequently, slow down to a crawl and should hug the right side of the byroad until he is in the act of emerging on to the main road, when he should gradually curve to the left, keeping a careful lookout for approaching traffic.

If on so emerging he observes, for the first time, an automobile or other vehicle in very close proximity, his action must depend on circumstances, but should be absolutely instantaneous, and as such rapid decision can only be acquired by experience, the beginner cannot exercise too great caution. If there is time, of course, he should rush across to his own side of the road, letting the approaching vehicle pass behind him.

It may happen, however, that the driver of the approaching vehicle by an error of judgment swings over to his wrong side of the road in order to get in front of the emerging car. In such a case, the driver of the emerging car may turn sharp to the right into the center of the roadway and face in the same direction as the car on the main road, thus leaving it room to pass on either side of him. Of course, if the car emerges from the side road at such a very slow pace that it can be brought to a stop within three or four feet, and if a wide turn has been taken in the first instance, the best course would be to jam the brakes hard on.

If an accident does occur under any circumstances, whether

it is the fault of the automobilist or not, the driver should always pull up and give every assistance in his power. It would also be advisable for him at once to take the names and addresses of any witnesses, and interview them as to their view of the causes which led to the accident, taking careful note as to what they say. Should proceedings result, this evidence would prove invaluable. See Accidents.

Courtesy on the Road.

As regards road users other than automobilists, no consideration can be too great if automobile owners desire to earn the good will and favor of the general public. If a horse is restive, the autoist should pull up at once, and if necessary stop the engine. Should a horse, however, suddenly and unexpectedly begin to back across the road, and the driver is uncertain whether he can stop his car in time to prevent a collision, it is generally best to go for the opening and try to dash through before the way is blocked. There should be no hesitation, however. The automobilist should either jam his brakes on or accelerate. Cyclists should be given a wide berth, especially when the road surface is in a greasy condition, and the practice of keeping on the crown of the road, regardless of other people's convenience, should be avoided. In process of time all other road users will become accustomed to motor car traffic, and it will then be possible to drive far faster in safety and without causing inconvenience than it is in many places to-day.

Consideration for Tires.

The reliability and durability of tires depend mainly on the way in which the car is driven. Excessive wear is caused by letting in the clutch suddenly, by stopping abruptly, by taking corners fast, and by neglecting to steer clear of broken stones where possible. It is also advisable when patches of broken stones cannot be avoided to declutch momentarily while the hind wheels are passing over the patch.

SELF-TUITION IN DRIVING.

The following hints and tips constitute another effort to convey to the mind of the reader how he may teach himself to drive his own car, presuming that the vehicle is delivered to him at such time and place as make it impossible for him to obtain tuition at the hands of an expert familiar with the special make of car he has purchased. Such preliminary instruction is always to be recommended, but the consideration of time, cost and locality may render it out of the question. Let us presume the new car to be a light one of some 1,200 to 1,600 lbs., driven by a one or two-cylindered engine, through friction clutch, change speed gear, propeller-shaft and bevel gearing on differential gear of live axle. The power of the motor may be anything up to, say, 10 horsepower. We will also presume that the car has been delivered, and stands in the garage its owner has secured for it.

The Initial Trip.

For the first attempt, choose the most solitary stretch of road you know of. The novice does not require any sort of audience when learning to drive. We take it for granted that our novice is not ignorant of the dispositions of the car he has bought, that he has perused as much literature dealing directly with his purchase as he could conveniently come at, and that he knows, for instance, the difference between the water and gasolene tanks. This is knowledge he must possess, for no good purpose can be served by charging the wrong tank with the wrong fluid. This sounds particularly elementary, but the mistake has been made more than once, with decidedly exasperating results. Also, we take it that our novice has informed himself of the use and direction of movement of the controlling levers—that is to say, the direction in which to move the sparking lever in order to advance or retard the spark, the proper actuation of the accelerator lever, to let in or cut out the governor (if such be fitted), and of the air lever (if the supply is so controllable). We must also presume equal knowledge of the use of the gear changing and

braking levers, and the clutch withdrawing and braking pedals. The car, of course, has been delivered with the electric wires all properly coupled up and the batteries charged. Here let us interpolate a little advice before proceeding further. Get these batteries recharged at the earliest opportunity. The first charge put into an accumulator does not last long, and the battery must not be expected to be on its best behavior until it has been recharged twice or thrice.

Charging Tanks.

Before the car is moved out of its garage the water tank should be filled with rainwater, if that is obtainable; if not, with the softest water than may be at hand. It is well to pour the water into the tank through a funnel fitted with a rather coarse strainer, as foreign bodies accidentally introduced into the water-cooling system cannot be withdrawn easily, and may do mischief. If your water system is provided with a drain-cock, open it before beginning to pour, and pour in for a little while it is running. This will prevent air-locks in the water system. Turn off the drain-cock—which, by the way, if present, should be found at the lowest point of the water system, when the jet has run solid—without spluttering or bubbling, and continue your filling until the level of the waste pipe from tank is reached, and the water trickles therefrom. Screw on cap of water tank. Now fill the gasolene tank. Among the accessories which should be supplied with the car will be found a funnel fitted with a gauze strainer. This must *always* be used when replenishing the gasolene tank, for dirt or other foreign matter introduced thereto will sooner or later give serious trouble, either by choking the gasolene supply pipe itself or choking up the spraying jet in the carbureter. It must be presumed that the lubricating tank is full, that grease boxes have been filled, and crank chamber, gear-box and differential gear case are properly supplied with the requisite quantities of oil. These are points which are often forgotten.

Starting the Engine.

Push your car out of its garage by hand, and then prepare to start your engine. Now, it is well to commence to perform the movements of levers, etc., necessary to this operation as they should in future be done, and, although this sequence of acts must vary in different makes of cars, we give them here as they are usually performed on a typical 10-horsepower car. The first thing to do—and be certain that you do it—is to make sure that your gear lever is in the free gear notch; to put on your side brakes, thus pulling out your clutch; to retard the spark almost to the lowest limit; and to get into the habit of doing these three things with certainty before you do anything else. Operation number 2. Move accelerator, or mixture lever, to the point which will give the easiest starting. In a typical car the accelerator lever is moved to a position about one-fourth down the rack segment, but with extra air admission most engines start with all or nearly all the air shut off at first. Operation 3. Open gasolene cock in gasolene supply pipe, allowing gasolene to flow to carbureter. If lever control to air supply is fitted, place that lever in best position for starting. Also, if your engine has been standing some time and is cold, it is well to turn the starting handle two or three revolutions, which will expel all common atmosphere from the tubes, combustion chambers and valve boxes. Operation 4. Switch on current and turn on cylinder lubricators. Operation 5. Press the stud in the top of float feed chamber of carbureter, so as more or less to flood your carbureter with gasolene. Operation 6. Press starting handle in until it engages properly with the engine-shaft, and turn round slowly until you begin to feel the compression. The handle should always be turned against the compression by a pull towards the starter—never the reverse—as then, should the engine back fire, the handle will only be torn from the grasp and no harm be done. On the other hand, if the compression is pushed against, and a back fire takes place, the starter is sure to receive a nasty jar, if nothing

more serious. So pull against your compression smartly and sharply, and the engine should start.

Ascertaining the Correct Mixture.

The next duty is to take steps to see that the engine is running to the best advantage. We must presume the reader knows which way to move the ignition lever to advance or retard the spark, and the necessary movement of the air lever to give more or less air; also how to actuate the accelerator lever or pedal, if you have got either or both. Advance the ignition until the engine begins to race. Then play a bit with the air lever, if you have one, or the ring cap opening and closing air ports to the carbureter, until your ear tells you that the engine is getting the mixture it likes best. If your ear does not inform you of this at once, you will very soon discover its proper note, which signifies that the engine is quite satisfied with the quality of the mixture you are feeding to it.

In the Driver's Seat.

If your circulating pump is friction-driven off the flywheel, as many pumps are, look at it and see that it is running properly. Assuming you have no pressure gauge, press any rubber connection in the water-circulating system between pump and cylinders to test by the pulsations there whether your pump is delivering properly or not. Now have a look at your cylinder lubricators, and see if they are feeding properly. The maker's catalogue should tell you how many drops a minute should be served; few catalogues do, but all should. With the car upon which these necessarily voluminous instructions are based, each drip should feed not less than five to seven drops per minute. It is usually easier to take your seat from the left than to squeeze in past the levers. Now sit down well and squarely before the wheel. Before you touch your side brakes lever, put your left foot on the clutch pedal, and depress it.

Manipulating the Control.

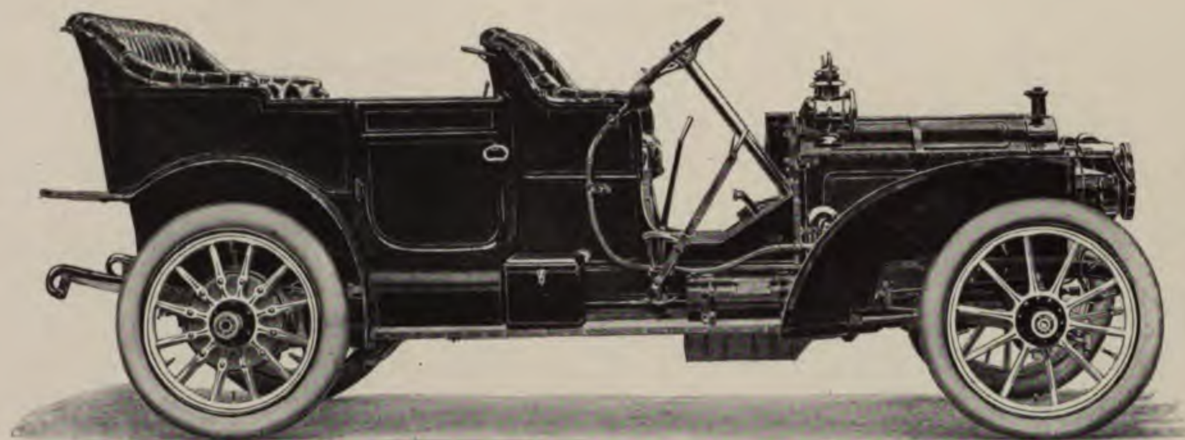
Now the clutch is withdrawn from driving contact with the flywheel, and cannot return thereto until you raise your foot.

So keep the pedal pressed down and take your side brakes off. See that the lever is right back. Now move the gear striking lever forward, so that the V-piece, or the trigger, whichever it may be fitted with, slips into the first speed slot or groove made to take it on the sector. Should the engine slow audibly, and grunt and snort more or less when moving the car away on the first speed, it is not running fast enough, and must be accelerated. Just how much you will soon find out. Now raise your foot gently—very gently—and easily until the car begins to draw away. An automobile should move away from rest just as the expert engine driver loves to take his flier away from a depot platform—that is, so that his passengers shall not be able to say when the train first moved. Keep your own side of the road, but not too close in. Now feel the steering, swing the car slightly from side to side, and learn how much lock a proportionate movement of the steering wheel controls.

Changing Gear.

Take a few corners on first speed. They will teach you just how much it is necessary to move your wheel to negotiate them.

Now to try a change of speed: With a governed engine, it is not necessary to touch the ignition or throttle or accelerator levers. Seize the handle portion of the gear-striking lever, and squeeze in the trigger lifter, if the lever is so fitted. Now press the pedal clutch right down to withdraw the clutch, and take the driving force off the car. With clutch so held out, move your gear lever forward until the trigger is past the first speed notch. Now release the trigger lifter, which you have hitherto been holding close to the handle of the gear lever, and let the trigger drop on to the smooth surface of the sector. Now slide the lever forward until you feel the trigger drop into the second speed notch, release lever, and raise your clutch pedal so as to let the clutch in gently. If a jarring noise is heard, it means that, instead of letting your trigger fall into the second speed notch before you let in your



The Packard "Thirty" 1909 Car.

clutch, you slightly reversed the operation, with the result that the teeth of the driven toothed wheel of the second gear were trying to dodge into the spaces between the teeth of the driving toothed wheel when the latter was going the faster, and spoiling their nicely tooled entering edges in the attempt. Try changing again several times until the gears can be engaged without a lot of noise.

On the Top Speed.

Now you are on your second speed, and you had better keep on it awhile. Try some more corners, and get accustomed to the control of the car on the second speed. Press down the clutch pedal gently from time to time in order to realize just how much declutching will slow the car; but be careful to let it in gently as before. Do not let the car slow down too much, as picking up again on the second speed is not good for the gear. Press down your brake pedal from time to time, and learn how much stopping power it provides. When you feel quite comfortable on second speed, and realize that you have control of the car, change on to third, but select a fairly good length of straight road to run on this gear. The change is effected exactly as above described; that is, press down clutch pedal, move your lever forward into the next notch, and when it is there, let your pedal come up gently.

In practising changing speed, it is well to select a stretch of down grade, not a hill, but just a very slight slope, as then the car will run on, and you may be more deliberate about your pedal and lever movements. Unclutch frequently as before, and use the pedal brake gently to acquire a knowledge of the effect on third speed. Practise this well, for by judicious use of the clutch and gentle applications of the foot brake, it is frequently possible to slow up just enough to get through traffic without changing down. There is one further instruction to be remembered, and that is, when you have changed on to your third or top speed, you should retard or throttle down the engine speed, for it is not wise for the novice to drive at the height of his top speed right off the reel. You

can accelerate the car gradually as you gain more confidence. The right thing to do is never to go fast till you perform every act of control automatically.

Attacking a Hill.

We must presume now that you have driven about on level roads until you can steer fairly well. The next thing to acquire is the knack of changing speed uphill in conformity with the gradient attacked. This, indeed, can hardly be called a knack—it is almost an instinct. First, wherever possible, it is well to put your car at a hill at its best gait on its top speed. It will rush up well at first, but gradually you will feel it slackening. You have your throttle wide open or your accelerator down already, and the only thing to be done in case the car will complete the climb on its top is to back down the ignition. Mind and do this, or the engine will knock—indeed, too early firing with the engine running slow has been known to break crankshafts. So back down as the car slows.

Presently it becomes apparent that it is not going over the hill on its top and the throb of the engine becomes accentuated. This is the moment—or, indeed, rather before, but you will learn it as you go—the psychological moment, to change down on to your second speed. Changing down is not so easy as changing up, and requires more practice. When properly done, grinding or groaning should in no way be in evidence, and there should be no forward or backward jerk of the car. It should glide on as though nothing had happened, and you alone in the car should be conscious that any change had been made. But, as we say, it is an instinct that comes by practice—sooner with some, later with more, and never with a few.

Withdrawing the Clutch.

There is one point, however, in changing down which may probably be observed. It is not necessary to withdraw the clutch wholly—indeed, some well-known drivers say that, if the change is effected at the proper moment, there is no need

to withdraw the clutch at all; but we do not advise the novice to try. The clutch should be withdrawn sufficiently to admit of it slipping, just how much varies with every car, and the knowledge thereof will only come with practice. Do not delay until the last moment for changing down to a lower gear, but drive upon that gear upon which you are running to the best possible advantage. Keep the engine running at its normal speed as long as possible by the manipulation of the throttle and sparking advance lever. When the speed of the engine begins to drop slightly change at once.

Gentle Handling.

In getting over the top of a hill, do not be in too great a hurry to change up again. The man who bangs in his second or his third before the engine is ready to take the car up shortens the life of his vehicle, besides laying up a store of trouble for himself. The true automobilist will come to feel for his car, and to learn just exactly what it likes and how it likes it. If you breast the brow of the hill on your first, wait until you hear your engine race before you change on to your second, and then wait again similarly before you slip in third. In pulling up, use your brakes gently. There are times, of course, when the brakes must be used for a sudden stop; but for all ordinary slacks, the throttle should be closed or the clutch pedal should be depressed and the car allowed to slow down naturally and easily.

Coasting Slopes.

Given average intelligence, the novice will find that a couple of hours' practice will be sufficient to permit him to manage his machine upon the open roads with safety to other people. Whenever the car will coast, at a reasonable speed without the engine driving, the driver will find that this is the safest, quietest, and most economical way of descending slopes. With the 10 horse-power machine, upon which these driving hints have been formed particularly, it has only been found necessary to press down the clutch pedal and withdraw clutch from

contact with the flywheel, letting the clutch in gently as the bottom of the slope is approached, so that the engine might take up the drive.

Picking up the Drive.

Just which speed should be attained before the clutch is let in will depend precisely upon what grade is next to be attacked; but if the descent continues gently or is followed by a level stretch, then the third or top speed should be engaged. The car gaining some momentum from the descent, the engine will be found to pick the drive up very nicely. If, however, the drop down is followed almost immediately by a rise, then the clutch should be let in and the gear engaged earlier, in order that a good rush may be made at the opposite slope. When you have learnt your car a bit, and feel fairly sure of yourself, it is well to accelerate the engine more or less for this sprint.

Throttling Down the Free Engine.

In descending hills with the engine free, it should be throttled right down, so as to cause it to run as slowly as possible, the ignition being well backed at the same time. Before striking a gear and letting in the clutch, the driver must not omit to open his throttle, advance spark, and get the engine running at a speed sufficient to take up the drive as soon as the clutch is let in. When a switch is placed ready to hand, the current may be cut off altogether, so that the engine stops, if the character and length of the descent will warrant this, so that when the moment comes for taking up the drive, the clutch let in, the current switched on, and throttle opened, the momentum of the car will restart the engine. The precise speed and grade on which one's engine can be started in this way is only to be known by practice, so that when our novice has acquired some skill and confidence he should essay to seek the same.

Driving on the Reverse.

Driving backward must be essayed carefully, and thought must be taken to press the clutch well out before moving the

gear-striking lever from the free to the reversing notch on the quadrant. It, of course, will be recognized that we are discussing a car on which all the speed-changing is performed by the movement of one lever. When an auxiliary lever has to be actuated to strike the reversing gear, then care must be taken to leave the forward striking gear lever in the free notch on the quadrant before the reversing lever is touched. With the clutch pedal pressed well down, move the lever to the reverse notch, and, keeping your foot firmly upon the pedal, turn partially round to the right in your seat, so that you can look square out of the back of your car over the center or side. In this wise, you will find it much easier to handle and steer your vehicle to a nicety when running astern than if you merely turn your head and look over your shoulder. Now let your clutch in gently, and as the car begins to go astern ascertain just the amount of helm it is necessary to give it for any desired movement. As your body is turned to the right, you have only your left hand for the wheel, but this will not be found difficult after a few trials.

The novice is strongly advised to select a wide and deserted stretch of road, and to practise reversing and steering backward until he has fairly got the hang of the effect of his lock when going backward. When you have traveled back to the desired position, do not fail to declutch, and if you are going to stop move your gear lever to the free notch, or take your reversing gear out with your reversing lever if your car is so fitted.

Entering the Garage.

Driving in and out of the garage or barn may give the novice some concern, and in this connection we would urge strongly that neither in coming out nor going in to such shelter should the beginner proceed on any other but his first speed. It is because cars have so frequently to be backed out of their shelters that we have already urged the novice to practise steering backward. Whether he will go into his garage backward and thus leave his vehicle in position to come straight out, or the reverse, must depend altogether upon

circumstances; but if there should be a drop into the stable of sufficient gradient to allow the car to run down by its own weight, we should advise him to drop in gently backward, with clutch out and foot on brake pedal, for it is less troublesome so to steer the car than to drive out backward up a slope.

After the Drive.

Now, when the drive is over and the car is to be put away, the man who wishes to keep all things in order and ready for an immediate start will devote a little time to replenishing with lubricating oil and kerosene. As soon as the engine is stopped, and the car is housed, lift the motor bonnet, and with your kerosene oilcan give the pistons two or three good squirts of kerosene through the cocks in the combustion chambers provided for the purpose. If your engine is innocent of these fittings, unscrew your sparking plugs and dose through the ports. Some people will tell you to use gasolene, but most prefer good kerosene. The effect of gasolene in loosening the piston rings vanishes in a very short time, and if your car remains unused for a day or two, the engine will not turn so easily when you come to start it up. Before turning off your compression cocks, or replacing your sparking plugs, turn the engine round several times by hand. This will cause the kerosene to cleanse the cylinder walls and rings. Fill up lubricators if they require it, and charge gasolene and water tanks, being careful afterward to screw down cap and vent screw on the former tightly.

Do not leave your switch on. If you do, you may find your battery run down when you next desire to drive.

If you have time at your disposal, it is well to make a careful survey of your car, and to see that no nuts have worked loose and that no bearing has run hot. Further, if you have any respect for your paint and upholstery, get a covering sheet of canvas and cover up your automobile before leaving it. Keep it covered always when standing in the garage.

Negotiating Road Risks.

When driving, always bear in mind that in the common

state of judicial and public opinion no excuse of any sort will serve you if you are damaged or cause damage by passing on your wrong side. To do so when a lumbering dray occupies the crown of the highway and your proper section of the road is blocked while there is ample room elsewhere is at times a great temptation, and we do not say that it may not occasionally be taken advantage of. But always bear in mind that the risk of vehicles closing in, of children of younger and of older growth darting out in front of you, is yours and yours alone. If you are one jot or tittle in the wrong, no matter how selfish or stupid those whose property or persons you may injure, you will have little or no consideration when called upon to pay the piper.

When overtaking traffic and finding by the time you arrive abreast of the vehicle you intend to pass that another coming in the opposite direction will be there before you, you should so speed your car that when the road is clear you will be able to go ahead without changing speed or using your brakes. If, however, you are on your top speed and your car has slowed down so that your engine is thumping, change down before you attempt to pass the vehicle in front.

Do your best to accommodate your speed to the traffic you are negotiating, so as to change speed and use your brakes as seldom as possible. By attention to this you will soon find your eye becoming educated to distances and speeds and you will be astonished to find how nicely these can be timed to drive with the least possible trouble.

ANOTHER LESSON IN DRIVING.

The methods that are recommended for learning to drive a motor car are almost as numerous as the makes of successful automobiles, and, in order that all the important points may be touched upon and nothing overlooked, still another set of instructions for new owners and drivers, from the standpoint of an automobilist of experience and authority, is appended:

Learning the Steering and Control.

A new owner will do well in the first place to study the construction and working of his car, as far as possible, while it is stationary. As part of this course, he should spend some time in the driver's seat, and accustom himself to the positions of the steering wheel and the various levers. Then he may venture out on the road in the company of an experienced driver, and by first resting his right hand lightly on the steering wheel, learn the effect of the different movements of the wheel on the course taken by the car. Gradually he will be able to take charge of the steering entirely from the left-hand seat, and then, occupying the driver's seat, may learn to steer the car on its first speed.

We will now suppose that you are able to steer the car, and have a general acquaintance with its various features, but otherwise are very much left to your own resources. Naturally, you are anxious to go for a drive; and here we may give a hint as to the route to be pursued on this occasion. Let it be a circular tour of short radius, and with home as center. In this way the risk of an expensive return in case of a breakdown is greatly reduced, and you will have the advantage, in all probability, of being well acquainted with the whole of the road traversed.

Preliminary Attentions.

Before starting out, the various nuts and bolts should be looked over, especially on a new car, and the brakes and steering gear connections should receive particular attention. The quantity of gasolene in the tank should be ascertained. If no gauge glass is fitted, a celluloid or glass tube may be inserted, a finger placed on the top, and the tube lifted out. The height of the gasolene in the tube will indicate the quantity in the tank. Or a clean white stick or paper spill will serve as a guide by discoloring the portion moistened. If more gasolene is required, it should be poured in through a funnel having a fine wire gauze strainer. This strainer should be supplemented by a piece of fine white cambric, as this, when satu-

rated with gasolene, resists the passage of any water that may happen to be in the can. Any water collecting in the cambric should be thrown away. See that the spout of the funnel is clean outside and in. A little gasolene or kerosene should be injected into each cylinder to free the piston rings and (in the case of the gasolene) to facilitate the obtaining of the first explosion. The lubricators should be turned on, and the caps of the grease cup given a turn—in fact, the car should be lubricated throughout.

After having seen that the gear lever is in the out-of-gear position, the carbureter should receive attention. It may be emptied of any stale gasolene it may contain. The mixture regulator may be set to cut down the quantity of air; and, the gasolene cock having been turned on, the float may be agitated so as to flood the carbureter. The throttle valve should be opened. The electric current should be switched on; and be careful to see that the timing lever is set well back. The next thing to do is to release the compression, if means for so doing are provided, but this is only usually necessary with large engines.

Starting the Engine.

The starting handle should be turned round clockwise (in most cars) until the resistance of the compression is felt. If this occurs as the handle is going downward, turn the handle back half a turn or so, and then try again until the compression is felt as the handle is beginning to come upward. The handle should be held with the fingers of the right hand under it, and the thumb not over it. When the compression is felt, give a strong and continuing pull upward, when, if all is in order, the motor will start. If the ignition were too far advanced, the explosion would drive the handle backward; and if you were pushing the handle down at the time, the chances are your wrist would be broken or so severely sprained as to be useless for some time to come. But if you are pulling up, the back fire simply unbends the fingers; and though you may be a bit scared, you are not likely to be hurt.

If the motor will not start after a few attempts, the ignition

may be slightly advanced, and different mixtures may be tried for the gas. If this will not do, try further injections of gasolene into the cylinders. Test the ignition to see that it is sparking properly. Sometimes it will be found that the valves having become dirty do not move freely; and if they remain open when they ought to close, the engine cannot work.

As soon as the engine starts, the ignition may be advanced somewhat, and the throttle partly closed. Your passengers having got aboard, you are ready to start. Hold the clutch out by the foot, and move the change gear lever into the first speed notch. If it will not enter easily, allow the clutch to engage slightly for a moment, and then try to get in gear again. As soon as the gear is engaged, the clutch should be let in very gradually, the throttle being opened to provide plenty of power. As the clutch engages, the car will move off, and the run will be begun. In starting, changing speed, etc., the finger catch (if any) must be grasped with the handle of the lever, but the catch should be released when it is clear of its notch, so that it may be ready to drop into the fresh notch as soon as the lever brings it opposite thereto.

Sometimes when the motor will not consent to start in the ordinary way, it may be prevailed upon to do its duty by letting in the first speed and clutch, and pushing the car. Of course, the driver must be in position so that he can steer the car and control it directly the motor begins to function.

Changing Speed.

After the car has got into its stride on its first speed, the gear may be raised to the next speed. To effect this, the sparking should be advanced so as to hustle up the motor, the clutch taken well out, and the gear lever moved, with as much decision and promptitude as possible, into the next higher notch. The clutch is let in again quickly, but gradually, and the whole operation should be performed with address, so that the speed of the car may not be sensibly diminished during the operation. Never put in a higher gear until you have become perfectly acquainted with the next lower one. It is very

tempting to see how fast the car can go, or how fast you dare let it go, but the temptation should be sternly resisted during your novitiate, otherwise you may never become an expert. After the car has fairly started, the mixture may be varied slightly until the best adjustment has been obtained; it should then be set with a little more air. The throttle, too, should be opened only so far as will allow of the car being driven at the desired speed with the ignition well advanced.

On reaching a hill, the speed of the car should be kept up at first by opening the throttle further and further as required. When the limit of this adjustment has been reached, the ignition should be gradually retarded, especially if the engine sets up a knocking noise. Some drivers are very skilful at coaxing cars uphill without lowering the gear, but this practice is not to be commended. If the engine begins to labor or the speed of the car has fallen to that of the next lower gear, that gear should be brought into operation. The motor should not be allowed to run too fast during the change; and the change should be effected quickly, as the speed of the car will fall very rapidly while the motive power is cut off. The directions for changing speed are soon given, but the amount of success with which the driver carries them out depends upon practice and skill.

Coasting, Braking, and Reversing.

Down grades will call for different treatment of the engine, according to their steepness and length. If the hill is only a short one, the engine may be left running at a slow speed and the clutch disengaged. If the hill is a long one, the motor may be stopped altogether, and the car allowed to run down by gravity; the quiet running will be found a welcome change. On nearing the bottom of a hill, the clutch should be gradually let in so as to start up the motor again. If the hill is very steep, the car should be kept well in hand from the very top. The first (lowest) speed should be put in and the current switched off; thus the engine will be converted into a pump, and will serve as an auxiliary brake, though this is not pos-

sible, of course, where the application of the pedal brake throws out the clutch.

Both the foot and the hand brakes should be tested soon after starting out on a run. If the car shows a disposition to get away down a hill, the clutch should be let in gently with the ignition switched off or the throttle quite closed. This will serve to limit the speed of the car. Broadly speaking, and in a general way, the brakes should be applied as little as possible. One sometimes sees a car come dashing up to its destination, and pull up in a few yards. This only shows that the driver has more control over the machine than he has over himself. It is smart, no doubt, especially for the tires.

Nothing is gained, but rather the contrary, by applying the brakes so hard as to skid the wheels. It is really much more clever to throttle down gradually and let the car arrive at the desired point upon momentum only.

On reaching one's destination, the current should be switched off, the gasolene tap closed, and the dripping of the lubricators stopped. The first and the last of these operations should be performed on stops of even short duration.

If it is desired to reverse the car, it must first be brought to a dead stop, the engine of course being left running, and the clutch disengaged. The reverse gear is now put in, and the clutch very gradually re-engaged. It is as well to practise reversing in a wide space at first, as the steering will be found somewhat awkward. Remember that if you encounter a hill that your car cannot climb, even on the first speed, it may be able to get up on the reverse, being driven backward, of course, for the purpose.

As a general rule, do not advance either the timing of the sparking or the opening of the throttle suddenly. The changes effected by these means should always be made gradually. And, finally, practise with your car until the control of it becomes perfectly automatic. Until then you can never trust yourself to do the right thing in an emergency.

Sources of Side-slip.

One of the worst evils the driver has to contend with is that of side-slip, and it is not to be surprised at if he loses his head somewhat on the first two or three occasions that this diversion occurs. The accident is nearly always compound—that is to say, the slipping in itself is not dangerous; but if the car strikes anything else, that thing will be damaged as well as the car.

It is a well-known fact in mechanics that if a sliding movement occurs between two contacting bodies, the one that is in motion may be moved at an angle to its path with comparative ease. In driving, therefore, on slippery surfaces, great care should be taken to avoid any variation from the true rolling motion of the wheels on the road. The variation may occur in several ways. For instance, if the engine be suddenly accelerated, the driving wheels will tend to spin round instead of merely rolling forward. Again, if the brakes be suddenly applied, the road wheels may rotate slower than the progress of the car corresponds to, and, indeed, they may cease to rotate at all, merely sliding along. Further, in passing over an uneven road the car may bounce, so that the wheels at times are actually out of contact with the road surface. Under any of these conditions, a very slight disturbing force will be enough to deflect the car from its straight course, and cause side-slip.

So long as the road is hard and dry, the friction between the tires and the road surface will be ample to prevent skidding; but if the hard smooth surface be covered with thin mud, or if a comparatively soft surface be covered with thick mud, the car will be prevented from obtaining a firm grip and may begin to slide at any moment. The same thing may, or will, happen on roads that are deep in dust; but the worst surface is undoubtedly ice that has begun to thaw.

Another source of side-slip is found in connection with street car lines. The lines themselves, or the tracks in which they are laid, often project above the general level of the road, or sometimes are depressed below the same, in either case forming ridges which tend to prevent the car traveling at an

angle thereto. The disturbing effect is greatest when the lines are wet. Probably the fact that cars are driven from the back and steered by the front contributes to their tendency to slip, as the rear part has a disposition to push round the front, on one side or the other. Of course, the greatest tendency to side-slip occurs when the car is being driven round a corner, as the centrifugal force then exerts a considerable lateral pressure upon the vehicle.

To Avoid Skidding.

To avoid side-slip our novice may take certain precautions. We will not say, do not take the car out when the roads are slippery, because it may not always be possible to follow that advice; and further, though the roads may be perfectly safe as a rule, you may find that a sprinkling cart has made them quite the reverse over more or less restricted sections. But when a greasy stretch is encountered, proceed slowly, especially in making turns. If the car begins to slip, keep your wits about you and begin to steer in the direction of the slip. This may be exactly contrary to your inclination, but it will tend to restore the grip of the wheels on the road; and as soon as this result is attained, you may begin carefully to steer again in the direction you wish to follow. As the camber or transverse curve of the road surface helps to promote side-slip, one should drive as much on the crown of the road as consideration for other traffic will allow.

In turning corners to the right, take the right side of the road; but in turning corners to the left, only take the left side of the road if you can see that the course is clear. If you keep on the inside of the corner, the transverse inclination of the road will help to get the car round. In taking corners, it is a good plan to declutch, and also to abstain from putting on the brakes; the chances of getting round safely are much increased if the car simply rolls round the curve. Street car tracks should be crossed at as nearly a right angle as possible. But if you are running along a crowded road laid with car tracks, and wish to get on to or off from the track, the steering

should be as gradual as possible, so that if the wheels refuse to take the ridges, the disturbing effect will be very small. One grain of comfort we can give: Side-slip is practically never accompanied by overturning, unless the car catches against some low object.

Non-slip Devices.

Prevention, however, is better than cure, and it is well to adopt some form of non-slipping device. Nearly all of these devices consist of some apparatus fitted to the tires and designed to cut through the grease, and so obtain a hold on the firm surface below.

A fairly effective non-slipper may be improvised by winding strong cord round the tire and felloes in spiral form. The ends of the cord must be carefully secured, and the cord itself examined frequently, and renewed as required. In any case it is best to fit all four wheels with the non-slippers.

Choice of Track.

Too many drivers simply take the road as it comes without troubling to select the best path. Possibly they are not aware that every bump means waste of power and increased wear to the car. But such is undoubtedly the case. One can often detect the fact that the driver is an experienced cyclist from the way in which he picks his course. We do not mean, of course, that the driver should keep the car perpetually on the wriggle, but simply that where he has the choice to make, he should take the line which will be best for the vehicle and most comfortable for the passengers. Thus a smooth surface is to be preferred to a rough one; dry ground is better than wet; the crown of the road gives better running than the sloping sides; and all reasonable care should be taken to avoid holes and loose stones. If a patch of new macadam cannot be avoided, it is best to drive up to it at a good speed and then declutch, so that the wheels merely roll over the stones, without being subjected to the additional strain set up by driving. If the momentum is not sufficient to carry the car the full

length of the patch, the remainder should be driven over quietly at slow speed.

Emergencies and General Conduct.

As a rule, the steering of the car, like the manipulation of the throttle and spark timing, should be performed gradually. It is very bad for the tires and most provocative of side-slip, to swing the steering wheel suddenly from one position to another. Perhaps the only times when this may be excused is when accidents would otherwise occur; as, for instance, when people, especially children, rush across in front of one without looking. Again, if a car begins to run back down a hill, the steering wheel should be promptly rotated so as to change the course of the car to a transverse direction. The brakes should be applied at the same time to prevent, if possible, charging into the bank, fence or other side of the road. It is much better to collide with the fence at the top of the hill than at the bottom—we mean, stop the car before it has gathered speed.

The automobilist's reputation being in many places none of the best, it is most important to drive as inoffensively as possible. It is not enough merely to have regard to the safety of other road users. One must avoid driving in such a way as to let them think that they have been in danger. It is almost, if not quite, as bad to offend a man's dignity by running him fine (as he imagines) as to knock him down. As a general rule, it is far safer to pass behind people than in front of them, when their path intersects your own. The horn or gong should be used fairly freely, though in blasts of short duration, the idea being rather to comply with the law than directly to profit by the signaling.

Never drive so fast that you cannot come to a dead stop within the length of road for the time being seen to be clear. Do not discommode or endanger other users of the road or the inhabitants of roadside houses by raising an excessive amount of dust, and do not bespatter pedestrians with mud. These things may seem a good deal to ask, but are not too much, we

think, to require from one who is after all merely taking his pleasure in public.

Speed Limits.

Speed limits are misguiding. There can be no harm morally in disregarding them where the road and its approaches can be seen to be clear; and they do not license one to travel up to them, where to do so would be to endanger the public. With the best intentions in the world, one is liable to travel too fast unwittingly at times. Thus, after a clear run at a good speed in the open, the pace is reduced to what seems a mere crawl on reaching a village. The driver contrasts his crawl with the speed he has just been running at; the village resident, on the contrary, compares it with the rate of progress of the local horses—and the resulting impressions are naturally somewhat different. A speedometer has its uses.

Do not confine your attention to the road merely; have an eye open for somnambulistic pedestrians with a weakness for leaving one path for the other with no regard for the traffic on the roadway. Treat them gently; it spoils their temper to wake them suddenly. Do not be satisfied with being in the right; keep out of scrimmages at all costs, for the automobilist cannot reckon on justice in these days. Observe the rules of the road, that is, keep to the right when meeting other vehicles, and to the left when overtaking them. But these rules must be disobeyed if necessary to avoid an accident.

Driving through City Traffic.

In driving through towns and cities one should be careful to see that the course is clear before attempting to overtake vehicles in front. It is not always necessary to swing round to the off side in order to ascertain the possibility of getting by, as many vehicles can be seen right through from end to end. When about to turn off to the right or left, in crowded thoroughfares, it is a good rule that the driver should hold out one hand to that side; and for stopping he should hold one hand straight up. As you approach a cross street, the windows you see in that street often reflect what is coming up to

your road, and by looking at the windows at your side you can also often see reflected the traffic that is coming behind you.

Pedestrians are allowed to walk where they like on a road provided they do not unreasonably obstruct other traffic. A led horse should be passed in either direction on the side of the man leading it, but this is convention rather than law. Street cars should be met and overtaken on the right side of the road.

Horses, Cattle and Cyclists

Horses are now fairly well accustomed to motor cars in most districts, but in remote places many owners have taken little or no trouble to educate their animals to the new method of locomotion, and special care must be exercised in dealing with them. In meeting a doubtful horse, it is best to proceed slowly and be ready to stop at any moment, whether the driver holds up his hand or not. Some horses have an unpleasant trick of looking perfectly unconcerned until almost up to the car, and then suddenly backing right across the road. Under these circumstances, the automobilist will have to act very promptly if a collision is to be avoided.

In overtaking nervous horses, it is best to drive quickly and quietly, so as to shorten the incident as much as possible. Unless time is precious, one may offer to spend a few minutes in improving a badly trained horse's acquaintance with motor cars. The horse owner's opinions on the subject are generally as much improved as those of his animal. Great care should be exercised in overtaking wagons carrying poles and other long burdens; as, if the driver draws his horse over to one side, the tail of the load swings across the road, and momentarily obstructs the other side.

The perfect control one has over a car tempts one to assume that all other road users are in equal command of their means of conveyance. But this is a very unsafe assumption. Every rider and driver has a period of inexperience; and even those who have got over their novitiate are liable to lose their heads at times, as, for example, on hearing a car coming up behind

"Couple-Gear" Electric Truck, Model A5.

them. The only safe course, therefore, is to see how much, not how little, space one can give cyclists, horsemen, and others. Remember especially that a cyclist's position is always more or less dangerous when the road is wet and slopes to the gutters.

Driving-axle—The axle of a driving wheel; a live axle, embracing the gear by which the wheels are turned.

Driving-belt—Any belt which conveys motion; a belt by which power is communicated from an engine.

Driving-chains—Two main forms of driving-chain are used on automobiles, namely, roller chains and block chains. The roller chain consists of a series of rollers connected by side links, each roller rotating loosely on a hollow core. The block chain, as its name implies, consists of a series of blocks, slightly concaved on the inner side to fit the sprocket and joined together by bolted side links. See Chain.

Driving Gear—The gearing by which power is transmitted from an engine, as the transmission gear of an automobile.

Driving Gear, Electric—See under Electric Motor.

Driving-lever—See under Levers.

Driving on the Brake—See under Driving.

Driving-shaft—A shaft from the driving-wheel communicating motion to machinery; a propeller-shaft.

Driving-side—The side of a driving-belt which is under tension.

Driving-wheel—A main wheel that communicates motion to other parts of a machine, as in the gearing of a live axle on a motor car.

Drop—A small spherical portion of any fluid which drops at once, or a globule of any fluid which is pendent, as if about to fall.

Drop-bar—In machinery, any bar having a regular descending motion.

Drop-brake—Same as Sprag.

Drop Forging.—A name given to a class of forgings in iron or steel which are made under a drop hammer. The hammer and anvil faces are shaped like half molds to the shape of the piece to be forged. The heated metal, generally the end of a bar, is held in position on the anvil, the hammer drops, and the metal is forced into the two molds. Pieces of irregular shape can thus be made of wrought metal faster and cheaper than they could be hand forged or cast. Most of the steel parts of motor vehicles are made in this way. The process is not applicable to pieces much larger than 12 inches in any direction, though long rods can be drop forged at each end in two operations. Drop forgings are generally more reliable than castings.

Drop-hammer—A machine for stamping, forging, etc., consisting usually of a heavy weight which drops between perpendicular guides.

Drop-oiler—A lubricator from which the oil emerges in drops.

Drop-valve—A valve in which the leaf or disk drops or swings downward.

Dropped Axle—An axle having a downward curve in part of its length, as a front axle of a motor car.

Dropped Frame—A frame that has a downward curvature.

Dross—The scum or extraneous matter of metals, thrown off in the process of melting; slag.

Drum—A short cylinder revolving on an axis, generally for the purpose of turning several small wheels. In a motor car a large pulley on which the brake-bands act in order to diminish the speed of the driving-gear.

Drum Armature—A dynamo-armature constructed so as to resemble a drum in form.

Drum Brake—See under Brakes.

Drum, Mud—A cylindrical chamber placed below a steam-boiler to collect the sand or mud deposited from the water used in the boiler.

Dry Battery—A primary battery in which the chemical solution is absorbed in some absorbent material to avoid spilling. See Battery.

Dry cells have an advantage (in the case of the non-electrical user) over accumulators, in that they offer a high internal resistance to the passage of current; therefore the dry cells used on motor cars never can give so large a current as wet accumulators on short circuits, and therefore, also, they cannot be so rapidly and so badly deteriorated by leaky connections and short circuits of brief duration. In fact, a "short" which is only temporary, say five minutes, will not reduce most dry cells to the state of utter uselessness that would result from five minutes' short circuit of an accumulator. Nothing but a complete recharge of the accumulator would make it usable after that, whereas merely waiting for half an hour might enable the dry cells to recover, by the internal depolarizing action of the manganese oxid (in Leclanchè cells), to the point of working a coil quite satisfactorily for many miles of traveling.

Four dry cells will give about the same working voltage as two accumulators if arranged "in series" (so that the plus and minus terminals alternate). Take care that the cases of the cells are insulated from the frame of the machine.

Measure the good condition of dry cells by connecting an ammeter in the primary circuit of the ignition system and noting the amount of current given by the cell. Accumulators are to be measured by a voltmeter which takes the normal current. In either case a 4-volt lamp gives a rough index of the voltage by its brightness, but the lamp should be selected to take about the same current as the coil.

In adjusting the contact maker keep the time of closed circuit as short as possible, while being long enough to effect ignition. This will greatly add to the life of the cells.

In a typical dry battery, the zinc, in the form of a vessel, contains a hollow carbon stuffed with absorbent silicate cotton. The electrolyte is a white paste of lime, sal-ammoniac, water, etc., next the zinc, and the depolarizer and black paste

of manganese dioxid, water, etc., next the carbon. The whole is packed with sawdust in a millboard case, provided with gas vent, and sealed with pitch. The E. M. F. is 1.5 volts, and the internal resistance 0.2 to 0.65 ohm, according to size.

Dry Steam—Steam that does not contain any admixture of mechanically suspended water.

Dual Ignition—Where two systems of ignition are used on the same engine, such as coil and battery and magneto, and especially where they are coupled up so to use the same coil or contact maker, the ignition is known as "dual."

Duc—The French name sometimes applied to a victoria-phaeton.

Duck—A coarse cloth, lighter than canvas, sometimes used for hoods, canopies, tents, etc. Frictioned duck, which is a kind of canvas treated with rubber, is used for tire casings.

Ductility—The property of solid bodies, particularly metals, which renders them capable of being extended by drawing without breaking.

Dumb Irons—The extensions of a car frame to which the springs are attached.

Duplex—Acting in two ways. In electricity, designating multiple telegraphy in which one wire is used to transmit two messages simultaneously. Duplex is also applied to any machine or part that acts in two ways or in a double capacity.

Durability—The two most important qualities an automobile should possess are reliability and durability; the former insuring freedom from trouble, the latter freedom from wear, An automobile is not necessarily good simply because when new it runs smoothly, climbs hills well, has plenty of speed, and in short, makes a good all-around demonstration; if, however, after several years of continuous running, covering say over 25,000 miles, it still continues to perform as well as when new, and without any big bills for labor or replacements, it may be termed a good car. The best cars, while excellent in all details, possess the paramount qualities of reliability and durability in the highest degree, and thus the largest measure

of satisfaction is assured to the purchaser, not merely for a few seasons, but for an indefinite period.

Dust—This is the "bête noir" of automobilists, but its effects are often exaggerated. It is really only when driving in company that the dust becomes a positive nuisance to the occupants of the car, though to the other users of the road it is always a great inconvenience.

Under ordinary circumstances, the trouble is caused by the suction behind the car, which draws the dust after it. Consequently, if there is a low back seat to the car the dust streams in, and not only smothers the rear passengers, but even reaches those in the front seat. A hood mitigates the dust nuisance, and some special dust screens absolutely prevent a single particle of dust from being drawn in from behind.

Until better methods of roadmaking are introduced the nuisance cannot be wholly abated. The use of oil and special road preparations produce an almost dustless surface for some time; but the real solution of the problem probably lies in the scientific designing of the car underneath, and altered methods of roadmaking.

What can be done at the present time is to give general indications thus: It is clear that a road surface containing no metal smaller than a pea would give rise to no dust from the effect of wind or the draft caused by cars. This corresponds to the German Kelinpflaster, or road armoring. Alternatively, if the general road surface were made of lumps of the recognized proper size, namely, the size of a walnut with the interstices filled in with the particles the size of a pea, all we would be concerned to find is a binding material of the nature of asphalt, but cheaper, which would take the place of the fine mud or road scrapings so commonly used at present. This corresponds to "carbolithic asphalt." Such a material must remain tough and not powdery when dry, must exclude water in time of rain, and must not wear slippery.

It is very simple to say this, but the question of cost of asphalt and the like is the grave impediment. Tar is cheaper

and the attempt to mix tar in the binding material is known as "tar macadam."

Difficulty was experienced in establishing a binding relationship between the tar and cold granite, so a European engineer substituted a hot waste product, namely, furnace slag, for the granite and got what he called "tarmac" (which must not be confounded with the granite mixture called "tar macadam"). As far as can be learned the product is successful, provided the slag be not over-limed and is preferably the byproduct of "forge" pig-iron furnaces, but even if it can be called comparatively cheap we are confronted with so immense a mileage of roads that if their remaking were contemplated in even the cheapest style of the present dust-producing manner, it would still be a titanic undertaking.

It is often asserted that the best class of macadam roads can be made practically dustless with very little additional first cost and with considerable ultimate economy.

Dust is raised by cars in two distinct ways:

1. By the wheels, which build up a dust feather or wall of small altitude because they kick it out by their slip (drivers), kick it out by the sudden release of the extension of the rubber of the tire where the tire leaves the ground, and splash the dust out of hollows in the ground.

2. By the air currents produced by the body. The rise and fall of the body on the springs produces in and out drafts from underneath the car. The vacuum formed behind the tonneau is filled by air which rushes up from all sides and from under the car. Then there is pressure produced by a box or obstruction placed at the back of the car which throttles the free passage of air under the car and both keeps the draft low down and near the ground produces a side wind outward.

A brief summary of the better known facts about dust, in so far as autoists are concerned, may be given as follows:

1. Sharp corners and excessive road cambers lead to slip and therefore to dust.

2. More dust is raised by cars from a rough road than from

an equally dusty road if it be smooth for an equal speed of traveling.

3. Watering the road moderately diminishes the dust. It is noteworthy that many grumblers living by the roadside have not realized this. Over-watering rots the road and increases dust later. Tar macadam, the spreading of crude oil on roads, and the spreading of oil emulsions in water on the road, are important palliatives.

4. Cars with smooth boat-shaped under surfaces are less dusty than others.

5. Cars with flaring mudguards fitted with leather flaps near the road level are more dusty.

6. Cars on high wheels well clear of the ground are less dusty.

7. Cars with large tool boxes or tanks at the back reaching down between the back wheels are more dusty.

8. Large car bodies are in some cases dustier than small ones.

9. Blowing off the exhaust near the ground is dusty.

10. Cars fitted with engines having an insufficient flywheel or an ununiform turning effort are more dusty.

11. Cars whose chassis are mounted on very easy springs having a large up and down travel will suck up the dust with each rise and fall of the body on rough roads.

12. Front wheels or rolling wheels raise less dust than back wheels or driven wheels.

13. Non-skid devices, such as small steel studs, etc., diminish the amount of dust raised, but increase the amount of dust created for future displacement by their crushing action.

Dust-apron—A protection, of cloth, metal, etc., for the under side of a motor car, to minimize the bad effects of dust on the machinery.

Dust-pan—A dust-apron made of metal.

Duty of an Engine—The amount of work in foot-pounds done by an engine or motor by the use of a given amount of fuel, current, etc.

Dynamics—The branch of mechanics which treats of bodies in motion; also the science and mathematical theory of the laws of force.

Dynamo—An apparatus for converting energy supplied by an engine, water power, or wind, etc., into electric current. It can be designed to supply currents of different kinds for various purposes, such as direct or continuous current, alternating current, etc. It is seldom used in motor car work, although a variation of it is found in the various magneto machines. A dynamo may be used for recharging storage batteries or accumulators, but it would not pay the motor car owner to go to the expense of laying down power for driving purposes. In one or two cars a dynamo is used to keep the accumulators charged, and is run from the engine. It automatically cuts itself out of circuit when the voltage of the accumulator reaches just above 4.

A dynamo and a magneto are really the same thing, save that with a magneto the field is made by a permanent magnet of hard steel. In the dynamo the field is obtained by winding the coils which carry part or the whole of the current round the soft iron core of the field.

The word dynamo is an abbreviation of dynamo-electric machine.

A series dynamo is one in which the whole current generated in the armature is passed through the coil of the field-magnets. In a shunt dynamo only a part of the current generated by the rotating armature is applied to excite the field-magnets.

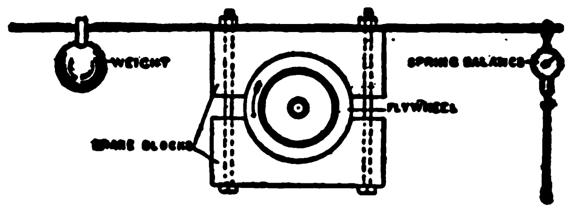
Dynamometer—An instrument to test the horse-power of any kind of motor.

To make a test:

1. Place the flywheel so that the wooden blocks can be tightened on it, and a fastener in the floor, to which the spring balance may be attached.

2. Alter the position of weight till it balances the combined weight of the spring balance and the lever to which it is fastened, the flywheel acting as a fulcrum, the blocks being free on it.

3. Start the engine and tighten the blocks until the engine makes a certain number of revolutions per minute, at the same time tightening the adjusting nut of the balance to keep the lever level.



DYNAMOMETER.

Note the number of revolutions per minute by the speed indicator and the stress indicated on the spring; then

$$\text{H.P.} = \cdot 0001904 \times R \times N \times P,$$

when R = Distance in feet between center of shaft and center of spring balance.

N = Number of revolutions per minute.

P = Reading on balance in pounds.

A dynamometer is sometimes called a Prony Brake, after Prony, the inventor.

Dynamometer, Balance—A simple form of dynamometer consisting of a steelyard. The force to be measured is applied to the shorter arm, while a weight is balanced on the longer graduated arm.

Dynamometer Coupling—A device inserted in a shaft by means of which the power transmitted may be measured.

Dyne—The unit of electrical force, being that force which in one second can impart a velocity of one centimeter per second to a mass of one gram. The word is an abbreviation of "dynam," from the Greek "dynamis," power.

E

Earth or Ground—The terms used when a wire carrying a current is connected to earth or some substitute by which the circuit is completed.

In motor cars the frame (French "masse") is taken to represent the earth. An insulated wire from one terminal is connected to the frame, and it is then said to be grounded or earthed, while the wire from the other terminal is carefully insulated from it. No current will pass until connection is made between these two paths and the circuit thus completed.

The object of using the frame to carry the current is that it simplifies the parts which would otherwise be necessary to complete the circuit with two insulated paths. For instance, instead of making connection between the engine and the sparking plug, the latter would have to be made with two insulated stems, each of which would have to be insulated from the other and also from the engine; such plugs are made, but unless very perfect in their construction, which means increased cost, they only double the existing trouble from this source. The coil also would have to be fitted with a greater number of terminals, and the contact maker or the contact breaker instead of, as now, making contact with its spindle, would have to be insulated from it, and another wire taken off leading back to the coil. See Ignition.

This term "earth" is so inappropriate in connection with motor ignition that a few words may be devoted to explaining it. Early experimenters with the electric telegraph discovered that, instead of connecting the two instruments by outward and return conducting wires, satisfactory results were obtained if the greater portion of the return wire was cut away, and the two short end portions connected to the instruments were sunk in the earth. Under these conditions the earth itself forms a conductor between the two ends of the return wire, and so completes the circuit. In motor car igni-

tion it would be impracticable to use the earth in this way, but the metal work of the car serves as an equivalent, and when it is availed of the old expression "earth" is used. The French term "masse" is considerably better, as being more general.

A "bad earth" in electricity is a faulty connection of a line with earth or ground.

Earth-flax—A fine variety of asbestos, the long filaments resembling flax.

Earthing—The connection of an electric wire with the earth or ground.

Earthing-wire—The wire by which a connection to earth is made.

Earthing-wire, Extra—See Grounding-wire.

Earth-wax—A mineral product found in carboniferous strata, also called ozocerite. It is a resinous wax consisting of natural paraffin.

Earth Wire—A ground wire. See Ground Wire, under Wires.

Earth or Ground Wire Connection—When the earth or ground wire is connected to the frame at some distance from the contact maker, the engine very often appears to be sluggish in action, and does not develop its best power. This is due to the voltage of the battery being of too low a pressure to overcome the many more or less clean metallic connections existing between the ground wire and its final contact to complete the primary circuit, as, although the resistance is small when the parts are first put in place, oil and dirt work in and increase the resistance to the passage of the current after working for some time. Therefore, the ground wire should be connected to any part of the motor near to the contact breaker, so that the current has to pass through the smallest number of joints. The battery will then give a good firing spark at the sparking plug, even when almost run down to 3.8 volts, and a marked improvement in the speed and power developed by the engine is noticed. Care should

be taken that the wire connection is made quite tight, or misfiring is certain to take place, the sparking plug often being blamed for this when it is faultless.

Easy Starting by Handle—See remarks on Prevention of Back-firing, under Driving.

Easy Starting of Engine—See To Start an Engine Easily, under Driving.

Ebonite—A hard, black substance used in electrical work for insulating purposes. It is composed of a mixture of india-rubber and sulphur vulcanized under great pressure and heat. It is tough and brittle, but will not stand excessive friction or heat. Usually called Hard Rubber.

It must be remembered that ebonite is indiarubber mixed with pigments and heated with a considerable quantity of sulphur to vulcanize it—at a temperature of about 280° F. Hence arise the following facts:

1. Ebonite will soften if heated anywhere near 280° F. and will be ruined—that is, become permanently soft if heated over this temperature.

2. Ebonite is an insulator, but will lose that quality on its surface if the sulphur in it is exposed to air for long periods, especially if exposed to the sun, because the sulphur oxidizes to SO_2, making sulphuric acid.

3. Ebonite being an indiarubber product does not stand oil well.

4. Ebonite expands and contracts with heat and cold considerably more than copper or brass.

Ebullition—The condition of any liquid when bubbles are rapidly forming in its mass and rising to the surface. This is primarily due to the action of heat, but may result either from the lowering of pressure beyond the escaping point of dissolved or compressed gas or from chemical activity.

Ebullition Carbureter—A form of carbureter in which the air is drawn through the liquid fuel and part passes off in bubbles. See Carbureter.

Eccentric—A device by which the rotary motion of a shaft

may be converted into a reciprocatory or up and down motion. It consists of a disk mounted upon a shaft out of its own center.

An eccentric is, in reality, a modification of the crank, and is a convenient method for obtaining a reciprocating motion of small amplitude, such as that necessary for steam engine valve gear, lubricator feeds, etc.

Fig. 1 shows a face elevation of an eccentric of an ordinary type. The center disk B, B, B, which is keyed to the

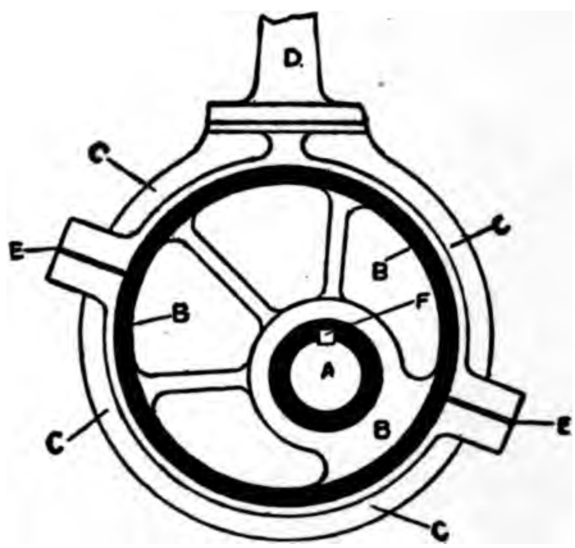


Fig. 1.—Eccentric.

shaft A by the key F, is of any suitable metal, and is set out of center half the distance of the travel required. This disk is called the sheave. Surrounding this sheave is the strap C, C, C, C, which consists of a metal casting made in two halves and bolted round. The joints are at E, E. This trap is a working fit about B, and has the rod D, which is hinged to the part to be moved, attached rigidly to it.

Eccentrics are used almost universally on steam cars for the operation of the valve gear.

The eccentric gives motion at every part of its revolution, as distinct from the cam, which does not.

Fig. 2 shows one of the commonest applications of the eccentric, viz., for the operation of the slide valve of a steam engine. Here A is the eccentric sheave and C the strap, the right hand half of which is made in one piece with the eccentric rod D. D is pivoted at F to a rod E sliding in a guide G, this being fixed to the frame of the engine. The

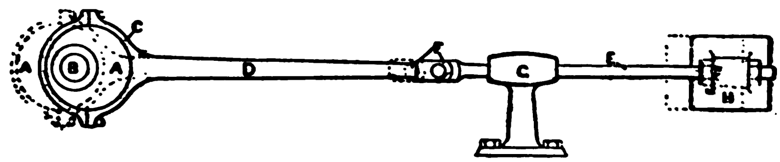


FIG. 2.—ECCENTRIC FOR SLIDE VALVE.

A, Sheave.
B, Shaft.
C, Strap.
D, Rod.
E, Rod operating valve H.
F, Joint connecting E and F.
G, Guide for E.
H, Valve.

other end of E carries the valve H, which slides on the valve face of the steam cylinder.

The dotted lines show the position of the mechanism with the eccentric sheave half a revolution away from its original locality, thus giving the maximum travel to the valve H.

Eccentric, Backward—The eccentric used in a steam-engine when the reversing gear is in operation.

Eccentric Cam—A circular disk used as a cam, in which the center of rotation is outside the center of the figure.

Eccentric, Fixed—The form of eccentric in general use, that is, fixed by a key to its shaft.

Eccentric, Forward—The eccentric used to operate the slide-valve of an engine in its forward movement.

Eccentric Gear—In machinery, the entire apparatus by which an eccentric is utilized; also applied to cogwheels which revolve on eccentric axes.

Eccentric Pump—See under Pumps.

Eccentric Rod—The rod attached to the eccentric strap for transmitting the motion of an eccentric.

Eccentric Strap—A metal band surrounding an eccentric; a rod attached to this collar conveys movement to the part to be operated.

Economizing Gasolene—Theoretically an engine will give its greatest power when running at its maximum speed, but under such circumstances, the gasolene consumption is high. Taking both gasolene consumption and power into account, the normal speed will generally give the best results, although the difference in the consumption may not be very great. With these facts in mind many automobilists conclude that the best means of economizing is to cover the distance in the fastest time that the car is capable of. In this they are mistaken, for there are other factors to be taken into account, and although, theoretically, a motor runs most economically at a speed invariably constant, this is only true when all conditions are equal—an impossible state of affairs. We will now deal with the factors which affect the question.

Windage—The wind resistance varies with the speed, not directly, but in accordance with the square of the speed. At moderate speed the wind resistance is comparatively slight, but it develops rapidly as the pace increases. The formula is as follows:

$$W^1 = 0.005V^2$$

in which W^1 represents the pressure of the wind in pounds per square foot, and V the velocity of the car in miles per hour. To get the correct resistance in each individual case the result given by the above formula must be multiplied by the area of the car subjected to the wind pressure.

Suppose, for example, that the car is traveling at 10.227 miles per hour, the resistance per square foot is 0.5229 lbs. If the speed is increased to 22.727 miles per hour the resistance becomes 2.5825 lbs. per square foot. At 44.454 miles per hour it becomes 9.8807 lbs. per square foot, while at 90.909 miles per hour it reaches the enormous total of 41.3222 lbs. per square foot.

In these calculations it is taken for granted that there is

no wind blowing. A strong adverse gale, needless to say, will materially increase the pressure per square foot.

Bad Roads—In the case of a rough surface or heavy mud, the power required to drive the car is greater, proportionately, as the speed increases.

The Condition of Car—The engine must be in good order and compression perfect to get the best results as regards economy. In fact, the mechanical efficiency not only of the engine, but of the transmission system generally, must be high.

Gasolene—The spirit used must be of good quality and high calorific value.

Ignition—This must be in perfect order, so as to give a "fat" spark and insure rapid and complete combustion.

Skill of the Driver—The ignition and throttle levers must be properly manipulated and judgment used as regards the speed. (See Driving.)

To sum up: With a full load on, the engine should be run as nearly as possible at its normal speed, and should only be raced in order to rush at a hill. With a light load on, as when descending a very gentle hill, the engine might be run somewhat faster, the throttle should be opened as little as possible, and, when a carburation lever is fitted, the mixture should be somewhat diluted. In descending steep hills, switch off and run free.

When a heavy head wind is blowing economy is effected by running the engine at less than its normal speed. With a tail wind the engine speed can advantageously be increased.

As regards the manipulation of the spark lever, the driver should endeavor to ignite the charge just as the piston is on the point of descending on the firing stroke, always bearing in mind that if the spark is feeble, the compression bad, or the mixture too weak or too strong, combustion will be slower than if all the conditions are favorable, and consequently the ignition will have to be advanced to a greater extent than if the conditions are normal.

By thoroughly grasping these various facts, the driver will,

"Couple-Gear" Electric Truck, Model A2.
Four-wheel Drive and Four-wheel Steer, Capacity 5 Tons.

if he so desires, be able to drive economically under all circumstances. See Driving.

Also see article on this subject (Economizing Gasolene) under Driving; and Gasolene Economy.

Economy of Motor Cars—The comparative economy of motor cars and horse-drawn vehicles has been a constant theme of debate ever since the former began to assume their natural importance in the field of transportation. It can only be said in a general way that this is a question for the individual owner. Inexpensive cars can be bought and operated cheaply—cheaper in fact than a decent horse outfit—and the range of initial cost and expense of maintenance is unlimited. For very many purposes, however—for recreation as well as for commercial use—there is true economy in buying and operating a motor car. This really applies to all sizes of cars, if the matter is regarded in a right light.

A good two-seated car properly looked after, is cheaper to run than a horse, and will accomplish four times the work.

A high-class two-cylinder four-seated car of moderate price and comparatively low horse power will cost about as much to run as a pair of horses, and will do four times the work. Two small cars will be cheaper to run than three horses.

In making these calculations we take into account interest on capital, up-keep, depreciation, cost of tires, and cost of labor.

Needless to say much depends on the way the car is looked after and driven. In extreme cases this might make as much difference as 50 per cent.

As far as the larger and more expensive cars are concerned, many owners who formerly maintained and often retain a large horse-vehicle establishment find true economy in the constant use of automobiles for all manner of social purposes. The tremendous advantage of the motor car in rate and sphere of travel must always be considered in figuring comparative expense.

Eddy Current—Also called Foucault current. See under Current.

Edge-cam—See under Cam.

Edison's Storage Battery—See under Storage Battery.

Eduction—The act of drawing out or bringing into view. Sometimes applied to the exhaust of an engine.

Eduction-pipe—An exhaust-pipe.

Eduction-valve—A valve for the passage of exhaust steam, fluid or gases; an exhaust-valve.

Efficiency—1. Heat efficiency is the ratio of heat converted into work to the total heat produced. If in a motor of any kind all the available heat contained in the fuel could be converted into work, that motor would be practically perfect. But in both internal combustion and steam motors great losses occur in the different parts—the boiler, the cylinder, and the exhaust. The chief gain which the internal combustion motor has over the steam is due to the elimination of the boiler, and the fact that the heat is generated exactly on the spot, where it is transformed into energy.

2. Mechanical Efficiency—In all moving parts friction takes place, which can only be reduced by high-class finish, good design, and proper lubrication, but can never be eliminated. The mechanical efficiency of a gasolene engine is the ratio between the amount of energy produced by the rapid expansion of the gas and the power available at the flywheel. The difference between the two represents mechanical loss due to the friction and inertia of the engine itself.

3. The "useful efficiency" of a motor is equal to the heat efficiency multiplied by the mechanical efficiency.

Generally speaking, in mechanics efficiency is defined as the ratio of useful effect to the expenditure of energy.

The essential difference between the motor car type of gas engine and the stationary gas engine is the paramount importance of "plant efficiency" in the former, and of fuel efficiency in the latter. In engineering textbooks, the efficiency of an engine is spoken of as the relation between the heat put into the engine and the work taken out of it. If the heat supplied (which is measured by the quantity of fuel) be large

compared to the work done in any given time, the efficiency is small or bad.

At the present day, the quantity of fuel burnt is not the prime consideration in engines for motor cars. This efficiency is important, but it does not occupy the first place. The primary consideration is to get the maximum amount of power from the minimum weight of plant.

Fuel Efficiency of Motor Cars—Only about one-fifth of the heat given to the best Otto cycle engine is utilized as power; there is room. therefore, for improvement. The loss of heat to the jacket is the most important loss in explosion engines.

The fuel consumption per H.P. per hour of a particular engine at two speeds, one of which was half the other, was found by experiment to be practically the same, but the fuel **efficiency** first increases and then decreases with the speed beyond certain limits. Diminished efficiency is indicated by the rise in temperature of the products of combustion, and is also due to the increase of the negative work, corresponding to the periods of exhaust and admission in the engine. The plant efficiency improves almost in proportion to the speed if the engine be designed for the higher speed.

The amount of heat passing to the jacket water rises slightly, and the temperature of the exhaust gases always rises in almost exact proportion to the decrease in efficiency of an engine.

In a particular experiment an improved efficiency resulting in an economy of 3 cubic feet of gas per H.P. per hour (equal to 11.7 per cent. of the total consumption of gas) was obtained by thoroughly cleaning the cylinder of exhaust products. At the same time the well-scoured cylinder can take in a large proportion of fresh gas, so that more power, as well as more efficiency, results from an effective and thorough exhaust, particularly if "scavenging" of the combustion space is adopted.

The ratio of indicated to useful work (which is about 90 per cent. for a steam engine), may be taken at 75 per cent. for an Otto cycle engine. Of this 75 per cent. about 90 per

cent. alone reappears for each reduction gear or transmission gear. Fuel efficiency also depends on good ignition timing. See Timing.

Efficiency of Battery—The current efficiency of an electric cell is the ratio between the ampere hours put in and the ampere hours which can be taken out. As a general rule for every 100 ampere-hours charge 80 ampere hours can be obtained on discharge from a cell in good order, and under normal conditions, although ignition batteries are generally so little looked after that their actual efficiency is frequently not more than 60 per cent. Many causes tend to this, but the worst is the habit of the ignorant chauffeur to short-circuit his cells with a piece of wire to see if they are in order.

The efficiency, in ampere hours, of a storage battery (accumulator) is less in proportion as it is discharged more rapidly, so that a brief short-circuit which may take out 100 amperes or more for a brief time may diminish the available mileage out of all proportion to the amount of the electric discharge.

Efficiency of Carbureter—The rate of outflow of fuel vapor from a carbureter. See Carbureter.

Efficiency of Engine—See under Efficiency above, also Compression.

Eisemann Distributer, The—See under Eisemann High-Tension Magneto below.

Eisemann High-Tension Magneto—In the Eisemann system of ignition a separate non-trembler induction coil is used in conjunction with the magneto, but a contact breaker on the armature spindle is substituted for that on the half-speed shaft of the motor. The current generated is a low-tension alternating one, but the contact breaker is operated in such a way that current is only drawn off at the moments of ignition, and these moments are timed to correspond with the flow of current in one direction only. Further, the moments of ignition are timed to correspond with those at which the most lines of force are being cut by the armature winding, and hence when the current is strongest. For these purposes

it is necessary that the rotations of the armature should bear a definite ratio to the rotations of the motor crankshaft. So the armature is driven by spur wheels, a chain, or other positive gearing, by the motor.

The contact breaker is mounted on a movable plate, in order that the sparking may be advanced and retarded in the usual way. It is of the make-and-break type, and is operated by a cam on the armature shaft. One end of the armature coil is grounded, and the other is in contact with a rotating terminal, which is connected through a carbon rod and a blade spring with the stationary platinum point of the contact breaker. The other platinum point of the contact breaker is mounted on an arm rocked by the cam, and this arm, being grounded, is in electrical connection with the grounded end of the armature winding.

A primary wire leads from the stationary platinum point to one end of the primary winding of the induction coil, the other end of which winding is grounded. A branch from the same wire leads to a switch which, when closed, makes contact with earth. The result of all this is that the armature current can always find at least one complete circuit through which to flow. The circuits differ in the resistance they offer to the flow, and when there are two circuits available most of the current will flow through the easier one. Thus, when the switch is closed and the contact breaker is closed (the platinum points being in contact), the circuit through the induction coil and the circuit through the contact breaker will both be available for the current, but as the latter circuit is the easier one, nearly all the current will flow through it. When the contact breaker momentarily opens, however, the current will have no choice but to flow through the primary winding of the induction coil, the secondary becomes excited, and the spark jumps the gap at the sparking plug. As with the battery system of ignition, the spark occurs at the moment of breaking contact, but here this corresponds with the commencement, not with the cessation, of the excitation of the induction coil.

The Eisemann Distributer.

For motors having two or more cylinders, a distributer is mounted over the armature, by which it is driven at half-speed through spur gearing; terminals are provided for the single high-tension wire coming from the coil, and for the several high-tension wires going to the respective sparking plugs. The high-tension current is led to a rotating arm which makes contact in turn with four equidistant metal blocks let into the face of the non-conducted distributer plate; and the blocks being in electrical connection with the respective terminals on the top of the plate, the high tension current is led to the proper sparking plugs at the proper periods.

Elastic and Flexible Connections—A perfectly-adjusted clutch would just transmit the full power of the motor and no more, so that in the event of an unforeseen shock the clutch would slip and prevent strain of the parts. This state of affairs being difficult to attain, more difficult to maintain, and not ideal in other respects even when secured, a good many transmission systems include an elastic connection between the clutch and the variable gear. This, if well-designed, contributes largely to smoothness of action and absence of injury; while the effects of clumsily letting in the clutch are reduced. In some systems, again, a flexible or self-adjusting joint is employed. The object of this is to allow the parts to accommodate themselves to any accidental disalignment, which would otherwise set up great friction and wear. Frequently the elastic device is also flexible.

Elasticity—The inherent property in bodies by which they recover their former figure or state after the force of external pressure, tension or distortion, has been removed. Thus, we speak of the elasticity of gases.

Elasticity, Coefficient of—The result obtained by dividing a given force or stress exerted upon a body by the resulting strain.

Elastic Fluids—Fluids which have the property of expand-

Columbia Electric Victoria Phaeton.

Columbia Mark 68 Brougham.

Baker Electric Victoria.

Baker Extension Front Coupé.

Pope-Waverley Electric Model 75 C.

Pope-Waverley Victoria Phaeton.

ing in all directions on the removal of external pressure, as gases and vapors.

Elastic Limit—In mechanics, the greatest amount of deformation that a body can stand and still resume its original shape when the strain is removed.

Elbows—A jointed or curved piece of pipe for smoke, water, gas, etc., or other coupling resembling a human elbow, designed to connect two lines running at an angle to each other.

Electric or Magnetic Clutch—See under Clutch.

Electrical Condenser—See under Condenser.

Electrical Wires—See Wires, also Conductor.

Electric Armature—See Armature.

Electric Buzzer—See Buzzer.

Electric Cars—See Electric Motor; also The Electric Car, under Motor Car.

The electric car is the ideal motor car in certain respects, says an authoritative writer on the subject, and the less perfect in certain others. The chief defect is in the means of supplying energy to the motor. The chief perfection is in the means of applying the energy and controlling it which the motor itself affords.

The continuous torque, perfect balance and high speed of which the motor is capable diminish the stresses on the transmission chains or gear and effect an economy of weight by dispensing with flywheels, gear, etc., which is, however, not sufficient to counterbalance the excessive weight required by the storage cells if these are to have any length of life and to travel for distances comparable to the mileage of gasolene cars. Unlike the gasolene engine, the electric motor may be made to turn at a constant speed regardless of the gradient, or at will at an approximately constant rate of working no matter what speed, within limits. These qualities afford immense advantages which are unobtainable with the explosion engine, though they are reached to a certain extent with those steam engines which allow a variable cut-off. To enable the gasolene engine to work at full power while

the car travels at a low speed, gear which is changed brusquely in steps is resorted to, and to enable the gasolene engine to work at a constant speed, no matter what may be the effort required by the road gradients, requires an efficient system of governing, and further makes it necessary that the engine shall be of such large dimensions as to be able to permanently give what may be only a momentary excess of load.

The electrical connections to the motor, controller and batteries of an electric car, though they require larger conductors than the electrical connections for the ignition of a gasolene car, are in most cases not appreciably more complicated and in many cases are more accessible. This means in practice that the electric car is, to a degree which is not always appreciated, simpler than the gasolene car, or, in other words, the ordinary gasolene car frequently carries in miniature the whole of the complication of the electric vehicle with an internal combustion engine and a gear-box in addition.

Turning from the perfections of the motor and passing to the difficulties which attend any attempt to make portable a supply of electric energy, we find a far less hopeful state of affairs.

The comparison between an electric car and the more usual type of motor car driven from an explosion engine may be briefly summarized as follows:

Advantages of the Electric Motor for Automobiles—1. A rotary engine of light weight giving a large torque at small speeds, able to stand overloads.

2. High internal efficiency of the combination of motor and its speed-reducing gear, if any.

3. A cheap mechanical equipment for speed control, owing to the possibility of dispensing with gear and clutch for change speeds.

4. Cheap maintenance, cheap lubrication, freedom from breakdown.

5. Absence of lubrication troubles, valve troubles, oil, dirt, smell, water-circulating troubles, pumps, cooling radiators, pipes, inflammable material in store, etc.

6. Extreme simplicity—three parts only; motor, controller and battery; ease of finding faults, and ease of measuring power used.

7. Cheap and clean housing; no fire risk compared to gasolene risks.

8. Ease of manipulation; flexibility of control owing to the absence of mechanical links, bell cranks, etc., allowing controller to be placed anywhere regardless of position of motor.

9. Thoroughness of control: reverse for all speeds, motor usable as brake, yet absorbing little power when driven by the road wheels when coasting.

10. No exhaust noises, backfire or muffler explosions.

11. Certainty and ease of starting from the driver's seat by a switch only.

Disadvantages—1. Weight of batteries, which more than counter-balance the advantage here gained on the motor.

2. Cost of battery, which outweighs the cheapness of the electric motor and the cheapness of mechanical equipment.

3. Inefficiency of battery, which outweighs the efficiency of the motor and absence of gear losses.

4. Rapid depreciation of battery, which outweighs the small cost of upkeep of motor, and economies due to having no clutches or gear.

5. Acid fumes and spillage, which may be set against the absence of smell and absence of oiling, and the depreciation by way of dirt which oil brings.

6. Loss of time for recharging, say one-quarter of the useful time.

7. Limited number of charging stations and distance possible on one charge.

8. Occasional necessity for losses in charging due to variety of pressure at different stations.

It will be noticed that the first among the disadvantages is the weight of batteries, and this, taken in conjunction with the volume they occupy, their liability to rapidly depreciate, and their small capacity from the point of view of the num-

ber of miles of country which can be covered on one charge, alone explains the slow progress made by a vehicle offering so many advantages. Another disadvantage of storage batteries is the serious effect resulting from short-circuiting the cells. No automatic protection which can be afforded to the batteries can be looked upon as otherwise then remunerative expenditure, and the lack of success which has from time to time troubled those who have instituted electric vehicle service is very largely ascribable to the lack of such protection.

Distance Traveled—The average electric automobile fitted up as a pleasure carriage for town work is designed to go, when new, about 40 miles upon one charge of the battery. In practice, says the authority quoted above, it is found that, with the loss of battery capacity with use and vibration, the occasional high discharge rates required up hills, and frequent re-starting and stopping in city traffic, the average distance which may be covered day after day by such a car is 30 miles, with the possibility of occasionally doing a little more. Any attempt to largely increase this distance (and many such attempts have been made for the purposes of advertisement of new batteries, etc.) has resulted in either so large an increase of the weight of the car that the proportion of deadweight to useful weight has become excessive, and the wear of the rubber tires has very greatly increased their cost of upkeep, or the battery has received such heavy discharges in proportion to its capacity that its life is greatly shortened and the cost of renewals augmented to a point which is unsatisfactory in ordinary routine work, however effective as an advertisement such long runs may be.

Consumption of Electrical Energy—Roughly speaking, it may be taken that, for town work, with the car in good new condition, the consumption of electrical energy is at the rate of 95 watt-hours per ton-mile taken from the battery in the car. If the road surfaces are exceptionally good and level, and made of good wood paving or asphalt, it is possible to use solid rubber tires instead of pneumatics without loss of comfort, and at the same time to obtain a slightly diminished

consumption of energy, say, to 90 watt-hours per ton-mile. But even if the usual route avoids all important gradients the consumption in town use may be taken as 100 watt-hours per ton-mile on an old and worn vehicle.

Weight—It has been for some time held that with batteries of the type now in general use, about one-third of the total weight of the loaded car should be batteries, the weight of battery being taken complete—that is, including all liquid, boxes, lugs and connections.

Method of Transmission—Almost all possible methods of transmission have been adopted in practice, for example: (1) The direct-coupled motor, in which the motor armature actually forms one piece with the front road wheel. Two motors are used, and the armatures are, by means of the controller, grouped in series or in parallel, according to the speed or torque required.

(2) The single reduction geared motor, in which two motors are used, one driving each front or each back wheel through one spur wheel and pinion; or

(3) The single reduction chain drive, in which one motor is used to drive a chain which passes over the middle element of the differential gear.

(4) The single reduction chain drive, in which one motor is used with the armature rotating in opposite direction to the field. The armature is connected by a chain to one back road wheel, and the field by a pinion and chain to the other road wheel, thus dispensing with the differential.

(5) The worm wheel drive, by which a single motor is placed in the front of the car, and drives a propeller shaft connected by means of a worm wheel to the middle element of the differential gear.

A feature which has unexpectedly turned out to be in favor of the electric automobile is its limited range of travel. This has the effect of obliging the owner to keep the vehicle in some town and there the inducement to him to contract for an inclusive annual sum for the maintenance of machinery, maintenance and painting of carriage work, maintenance of

batteries, supply of driver and of a substitute car in case of breakdown, is such that this plan is often successfully adopted, especially in Europe. On the other hand, the long range of distance of gasolene or steam cars and the danger of their being subjected to rough treatment in distant places by unskilled attendants, has rendered the practical development of any such maintenance system in their case almost out of the question, save for an annual sum which is practically prohibitive.

This does not indicate that the gasolene car is dearer to run, for on the contrary it is appreciably cheaper; but it does mean that the very limitations of the electrical system facilitate supervision and the formulation of maintenance contracts which many owners of cars prefer owing to the difficulty of getting good drivers and the advantage of having a stand-by car in an emergency.

Electric Conductors—As the quantity of insulated conducting wire on a car is small, the very highest possible quality of conductor and insulation should be insisted on. The conductor may, with advantage, have a much higher conductivity than is usual. The fine flexible strands should be twisted up together with a very short "lay," not because any strain is ever put upon them, but because they will have to withstand a continual vibratory motion, and a flexible laid up with thick wires is not well adapted to withstand quick, short vibrations. The sharpest bending obviously occurs at every terminal. This must be obviated as far as possible.

On no account should the flexible conductor be soldered anywhere near a place where it may have to bend even a little. Metal terminal pieces, such that the flexible is slipped up and down between notches which grasp it allowing of its extreme tip being soldered, and having a curved shoulder which grasps and protects the indiarubber tape and braid over a considerable length, must be provided, and even then a tight-fitting rubber tube should be slipped over the metal shoulder so as to grasp both it and the flexible cord behind it. See Terminals.

If a wire is held at one end rigidly and passes through a hole in some part, such as the dash or footboard, which can move with relation to the rigidly fixed end owing to the natural slight distortion of the parts of car in motion, care must be taken that sufficient slack is allowed in the wire not to resist the free relative movement to the parts.

Minute care and perfect cleanliness is needed to make adequate electrical contacts on the primary circuits on motor cars on account of the small voltage (four volts).

Equally minute care and cleanliness is required to keep in order and avoid leakage of the secondary of high voltage circuit, say 27,000 volts on open circuit.

Notice the different object for which the cleanliness is required in the two cases. In the first, owing to the small voltage, the difficulty is to get the copper terminals bright and clean, to enable the current to flow; in the second, the difficulty is to keep the insulation clean, dry, and good enough to prevent the current from flowing in the wrong place.

Electric Connections—A term generally used to denote the connection made with the terminals of any piece of electrical apparatus. For instance, each primary cell has two terminals, positive and negative, which, to make up a battery suitable for ignition purposes, have to be connected in such a manner as to make a complete circuit.

The connection is made by firmly fixing a piece of wire or other conducting material to each terminal.

The different devices for attaching the ends of wires to the different terminals on the electrical appliances are dealt with under the heading Terminals. Generally speaking, the only electric connection likely to be required in motor work, other than the connection of the wires to terminals, is the joining of the ends of two wires together. This is done by stripping off the insulation and untwisting the strands of the wire for a short distance on the end of either piece, and twisting them together again around each other, then soldering the whole together and replacing the insulation by rubber insulation tape wound round while slightly heated. It

is important that the flux used in soldering the wires should be powdered resin; the ordinary spirits of salts adopted for soldering should never be used, for it sets up corrosion accentuated by the passage of the electric current.

The essential point in all electrical connections is to keep the resistance as low as possible. If the connection is loose, dirty, or corroded, or if the pressure is insufficient, heat is produced at that point, and the resistance to a current of electricity is increased in proportion, causing wastage and often doing damage.

Electric Contact—See under Contact.

Electric Controller—See Controller, also Electric Cars and Motor Car.

Electric Conversions—There are owners of old cars who contemplate having their electric ignition converted from the trembler type to the wiping contact. Many have attempted to carry out this conversion in conjunction with an ordinary coil, and have been somewhat surprised to find that, instead of improving their spark, it has spoiled it. It must be remembered that when the wiping contact is employed, a trembler coil must be used to obtain the best results. It is possible, of course, to use an ordinary coil by inserting in the circuit an auto-trembler.

Electric Discharge—The outflow of a current from a battery, cell, etc., when the circuit is closed. See Discharge.

Electric Energy—The energy possessed by a system because of electric charges resident in or of currents flowing in the system. The energy of a charged body equals one-half the charge multiplied by the potential of the body.

Electric Field—Any space in which there is an electric stress.

Electric Fittings—See Electrical Items under Overhauling.

Electric Fluid—A theoretical fluid, imagined to account for electric phenomena. It is now discredited by scientists.

Electric Ignition—See under Ignition.

Electric Car Models—Columbus Buggy Co.

Rauch & Lang Single Coupe Electric.

Rauch & Lang Electric Stanhope.

Electricity—Electricity is one of the many forms of energy, such as heat, light, etc., governed by its own laws, and having distinctive phenomena. Its name is taken from the Greek word for amber, "electron," from the fact that a stick of amber rubbed with a piece of woolen material has the property of attracting small pieces of paper and other light bodies.

A number of experiments carried out by scientists for a long period of time, and continuously advancing, led to the knowledge that all substances fall into two great classes as regards their electrical properties.

These two classes of bodies are called conductors and non-conductors or insulators. All bodies will produce electricity by friction, but the second class, or conductors, require to be insulated from the ground and surroundings by the first class, or insulators, to prevent the electricity escaping. All bodies will conduct electricity, but the first class insulators offer so great a resistance to its passage that a current at an enormous tension is required to traverse them, and for practical purposes they are as efficient as real non-conductors, did such exist, with currents up to fairly high tension.

It was first thought that there were two kinds of electricity which were called Positive and Negative, but later it was discovered that all electricity was the same in kind, but differed in degree. The old nomenclature is still retained, but it is now used to imply that if one body is electrified to a higher degree than another they are positive and negative to each other.

Up to the discovery of the voltaic cell by Volta all experiments had been carried out with electricity produced by friction, in machines fitted with cylinders of different materials that when rubbed produced electrical energy which could be collected. Machines made on the same principles, called influence machines, are still used for experimental purposes, where a current of high voltage and small amperage is required.

Primary Cells—With the advent of voltaic cells, now called primary cells, a new field was opened for experiment and

investigation. A current of electricity produced by this means is due to chemical action. With certain substances placed together in certain positions, it was found that certain changes occurred in their chemical composition, which changes produced a flow of electricity from the substance most acted on to that which was least acted on.

The chemical action in these cells is analogous to that which takes place in a furnace. One of the elements is fuel, and as it is consumed in the cell, electrical energy is developed. See Battery.

Accumulators or Storage Cells—To Planté is due the discovery of secondary cells or accumulators, often called storage batteries, though differing from the true storage battery. The action in these is also chemical, but with this difference, that by passing a current of electricity through them from some outside source, it is possible to exactly reverse the chemical changes that have taken place during discharge, so reproducing the original conditions. With accumulators it was found possible to store the energy derived from primary cells, and then, by connecting the cells up in different ways, to obtain a current of any amperage and voltage that might be required. See Battery.

Dynamo—The last great discovery with which we are now concerned resulted from combining the phenomena of magnetism with those of electricity in a machine, the dynamo, in which the lines of force between the two poles of a magnet are continuously cut by coils of insulated wire, thereby inducing a current of electricity to flow in the wire, which can be collected and utilized for outside purposes. See Ignition.

The uses of electricity are so wide and varied that it is only possible here to mention those in connection with motor cars. These are ignition, motive power, and light. The principal instruments employed are primary and storage cells, induction coils, dynamo and magneto machines, and motors, and these will be found more fully treated under their respective headings.

The three units of measurement in electricity most useful to remember are:

The Volt, which expresses the force or pressure of the current, just as the pressure of steam or water is expressed in lbs. per square inch. The unit of the volt is calculated by the pressure or difference of potential which will send a certain quantity of current, defined as an ampere, through a resistance of one ohm.

The Ohm, or the unit of resistance which the conductor offers to the flow of current. The ohm is calculated by the resistance of a certain length and thickness of a column of mercury having a known cross sectional area, and a known length at a fixed temperature.

The Ampere, or the unit of current which is induced to flow from one body to another by a difference of potential of one volt between them, through a resistance of one ohm.

The three units are connected in the following equation:

$$\text{C (current in amperes)} = \frac{\text{E (Electric force in volts)}}{\text{R (Resistance in ohms)}}$$

If two bodies having a difference of potential between them of 4 volts are connected with a wire having a resistance of 2 ohms, a current of two amperes will flow in the wire.

High and low tension are merely comparative terms. For instance, these terms are used to discriminate between the two currents of different potential required for electric ignition in a motor car, and merely mean that the one is at a very much higher voltage than the other, for there is no hard and fast line dividing one from the other.

Electricity, Elementary—See under Ignition.

Electricity, Free—The charge on an insulated charged body which is so far removed from the presence of any other charge that it can be considered as existing alone. As every charge is accompanied by another charge of equal quantity and opposite name, none can be absolutely free.

Electricity, Steam and Gasolene, Comparative Advantages of—The following view of the comparative advantages of electric, steam and gasolene cars is from an unbiased source:

The three systems all have their advocates, and all are good in their way. In order to facilitate an impartial judgment, we will tabulate the points for and against each. The difficulty lies in appraising the various points in due proportion. And it must be premised that the points are of only general application; in some cases the advantages and disadvantages might be actually reversed.

The pros and cons of the gasolene car are:

Advantages.	Disadvantages.
Capability of running long distances without replenishing supplies.	Occasional unpleasant exhaust, if driver is careless.
Large range of choice.	Physical starting (sometimes).
Wide dissemination of expert knowledge.	Gear changing (scarcely worth mentioning on a good car).

The advantages and disadvantages of the steam car may be briefly summarized as follows:

Advantages.	Disadvantages.
Great range of power, easily controlled.	Limited number of makes to select from.
Quietness.	Delay in starting.
Freedom from vibration.	Close attention required to indicators.
Easy restarting.	Frequently visible exhaust.

These disadvantages have interfered with the lighter type of steam car. The heavier type, closely approaching the gasolene car in general appearance, has a good following.

The points in favor of the electric car and those against it are as follows:

Advantages.	Disadvantages.
Quietness.	Expense of running, owing partly to the weight of batteries.
Absence of vibration.	
Simple and efficient gearing.	

Advantages.	Disadvantages.
Facility of control.	Limited range.
Cleanliness.	Great weight of batteries.
Easy starting.	Time taken to recharge.
	Liability of batteries to injury.
	Slow speed for sustained running.
	High initial cost.

The electric car is therefore not as popular as the gasolene car for touring purposes; but for town work, such as professional calls, attending theaters and the like, indeed, where cost is not all-important, the electric car is most suitable and is highly appreciated.

It is only fair to state that efforts are constantly being made —and with a fair degree of success—to overcome the disadvantages named above in all three types of car.

Also see article by another authority under Electric Cars.

Electricity, High Tension—The form of electricity used in jump spark systems of ignition. It implies a current of high intensity or pressure as distinguished from its quantity, but the term is always relative. See Electricity.

Electricity Station, Recharging at—See under Battery.

Electric Lamps—See under Lamps.

Electric Motor—In construction the electric motor is practically the same as a dynamo (see Dynamo), but as it is used for a different purpose, and often under very different conditions, some changes have to be made to secure efficiency and reliability. By a different arrangement of the armature wiring, a greater power to start from rest under a load can be obtained.

The electric motor is not self-contained like the internal combustion motor, but is equivalent to a steam engine without the boiler, as it only transforms one form of energy into another. The speed can be regulated by the supply of current, and it is almost silent in running. Like the internal combus-

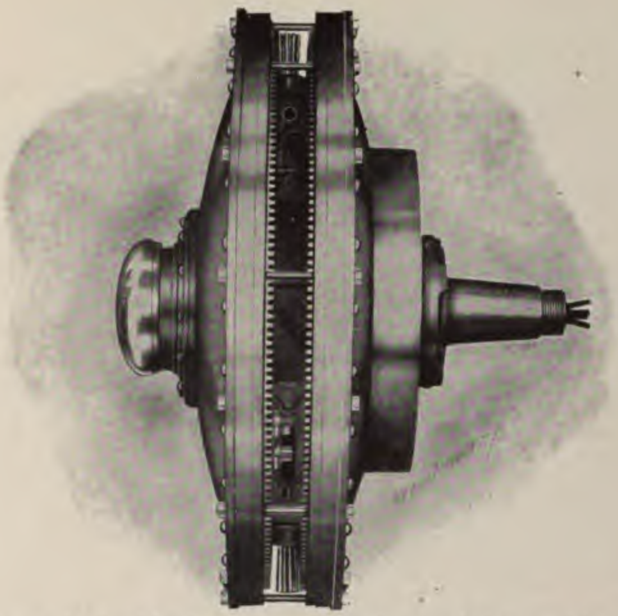
tion motor it can be started at once, and has the further advantage that it is self starting. As electric motors for traction work have been in use for many years, there was no necessity for motor car builders to design any special types for themselves, though many improvements have in fact been made.

Principle of the Motor.

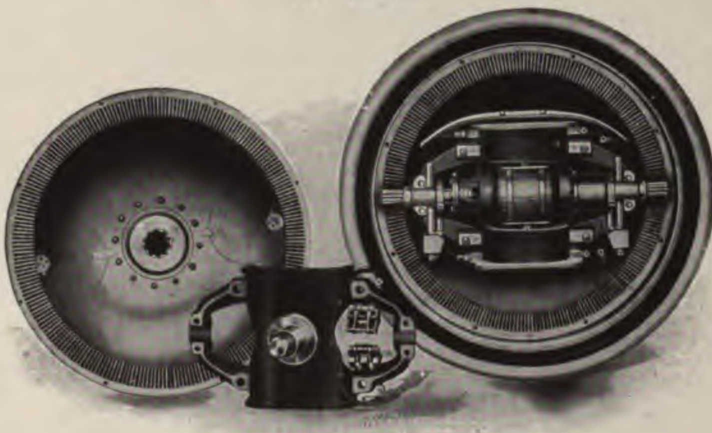
An electric motor is similar to a dynamo, but instead of converting motion into electricity, it converts electricity into motion. The motor consists of magnets and an armature, as in magneto ignition, but on a much larger scale. Further, the magnets are not permanent, but are excited by the passage of current through insulated wire wound upon them, the current being derived from the battery on the car. Magnets thus excited by an electric current are distinguished as electro-magnets. The faggoted core of an induction coil is another example of an electro-magnet. The magnets are arranged around the armature, and their ends are provided with pole pieces, curved to form a bore within which the armature can rotate freely but with very little clearance. There are generally four magnets, and the poles are arranged alternately, negative and positive. The cylindrical space inclosed by the poles is known as the magnetic field, and the magnets themselves are called the field magnets.

The armature core is laminated, and has a large number of radial grooves (not merely two, as in an H-section magneto armature), and each pair of grooves is wound with a separate coil of insulated wire. The ends of the respective wires are connected to a series of copper sectors, severally insulated from one another, and together forming a cylinder arranged concentrically around the armature spindle, at one end of the core. This cylinder is called the commutator.

The sections of the armature constitute a series of rotatable electro-magnets, and they are excited in turn by current passing from the battery through two carbon brushes bearing upon the commutator. As each armature magnet becomes excited, it is operated upon by the adjacent field magnet and caused



Complete wheel with tire removed to show relative position of the two pinions.



Side of wheel and front of motor removed, giving access to the armature, field coils and bearings.

Couple-Gear Motor Wheel,
as Built for Four-wheel Drive Five-ton Truck.

to rotate. The rotation withdraws that section from the brush and brings the next under the influence of the current, and so on, with great rapidity and smoothness. Some electric motors run at two or three thousand revolutions per minute, but those working at six hundred to eight hundred revolutions per minute stand sudden augmentation of current better. By introducing a reversing switch, the car can be run backward when required, and the motor can be used as a brake. When braking, the motor is sometimes driven, as a dynamo, by the car, and tends to recharge the battery, but the profit accruing is not great. The motor should be carefully incased as a protection against wet and dirt.

The Controller and Driving Gear.

The power of the motor may be regulated in different ways. An adjustable resistance may be introduced into the circuit; or, if the motor be series wound, the current can be sent through either the whole or through only a portion of the windings of the magnets, thus varying their strength. This system offers facilities for comparatively fine graduation of the speeds. Another way of regulating the power is by variations of parallel and series coupling of the cells in the battery. Each cell is usually coupled to its neighbor in series, but if the battery is arranged in four groups, with say ten cells in each group, then the voltage of each group will be twenty. The changes may be rung on the four groups thus:

All four in parallel (all the four negative poles coupled to one terminal, and all the four positive poles coupled to the other terminal), twenty volts.

Two pairs, each in series, and the pairs themselves in parallel (the positive pole of group No. 1 coupled to the negative pole of No. 2, the positive pole of group No. 3 coupled to the negative pole of No. 4; the negative poles of groups Nos. 1 and 3 coupled to one terminal, and the positive poles of groups Nos. 2 and 4 coupled to another terminal) forty volts.

All four in series (the positive pole of each group coupled to the negative pole of the next, leaving the negative pole of

group No. 1 and the positive pole of group No. 4 to be coupled to the two terminals respectively), eighty volts.

It will be observed that the proportions of speed between the parallel, series parallel, and series couplings are as 1, 2, 4, which are rather course gradations.

The instrument for regulating the power of a motor is called a controller. It is provided with a handle, the movement of which to different positions effects the changes of speed, or rather power, as required. At starting, the current is switched on and the controller turned to the first speed position, when the car moves off at a slow pace. When under way, the handle may be turned to the higher speeds in turn, and so on.

The actual driving gear of an electric car is very simple. If only one motor is employed, a pinion may be mounted on the armature shaft and gear with a large wheel on the balance-geared live axle. Or the necessary speed between the armature and the live axle may be made in two steps instead of in one. If two motors are used, the armature pinions may be made to gear with large toothed wheels secured directly to the two driving road wheels; no balance gear is necessary in this case, as the motors adapt themselves automatically to the different degrees of motion required by the two driving wheels in making curves. This feature enables the front wheels to be driven if desired, but the rear wheels are nearly always chosen as the drivers. There is an incidental advantage in the use of two motors, in that should one fail it may be possible to get home on the other.

Electric Power—The electro-motive force of a current of electricity.

Electric Stress—Electro-motive force due to the attractions or repulsions of electric charges. If a glass plate be coated on both sides with tinfoil and the two sides be oppositely charged, the glass will be deformed by the electric attraction or force.

Electric Switch—An arrangement for bridging a gap in a

conductor, so that the circuit can be completed or broken as required. See Switch.

Electric Torch—For examinations at night time, where any lamp but a Davy would be dangerous, the electric torch comes in very handy, as it may be used in any position. Its value will be brought home to any one who may have to repair a leaking gasolene pipe on a pitch-dark night.

Electric Vehicles—See under Electric Cars, Motor Car, and Electricity, Steam and Gasolene, Comparative Advantages of.

Electric Welding—The union of two pieces of metal by means of pressure and the localization of an intense electric current at the point of meeting of the parts to be welded.

Electric Wire—Insulated wire for ignition purposes, etc.

Electrode—The path by which electricity passes from or into a conducting medium such as a solution. Applied specifically to the ends, usually in the form of plates, of the conductors or wires leading from the source of the current and terminating in the medium conveying the current. The positive electrode is called the anode and the negative electrode is called the cathode.

Electrodynamics—The laws of electricity in a state of motion, or the action of electric currents upon each other and upon magnets.

Electrograph—The automatic continuous tracing of an electromotor, used as a record.

Electrolysis—The process of chemical decomposition of various substances by the electric current. Thus, when an electric current passes through an aqueous solution of ordinary salt, the salt is broken up into its constituents, sodium and chlorin. This process is called electrolysis and the constituent parts are known as the ions.

Electrolyte—The acid or alkaline fluid contained within a cell. The agent which acts upon the positive and negative elements to produce a current of electricity. See Battery.

Electrolyte Evaporation—See under Battery.

Electro-magnet—A core of magnetizable substance, such as soft iron or nickel, placed within a coil or helix of wire through which an electric current is passing. This magnetizes the core by induction, but the magnetic state thus induced persists during the passage of the current only and disappears almost wholly with its cessation.

See Principle of the Motor, under Electric Motor.

Electro-magnetism—That portion of physics which treats of the various actions and relations between currents and magnets, as the deflection of a magnet by a current, and the magnetization of a bar of iron or steel or nickel by a current flowing in a coil wound upon the bar.

Electro-metallurgy—The separation of metals from their ores or alloys by electrolysis.

Electrometer—An instrument for measuring differences of potential by the effects of electrostatic force. It consists of at least two conductors, one movable with respect to the other, which can be charged to the difference which is to be measured. From the motion of the movable conductor so produced, or the force necessary to prevent such motion, the difference of potential is inferred. The term is sometimes applied to instruments which merely indicate a difference of potential, more properly called electroscopes.

Electromobile—An automobile propelled by means of an electric motor. Such vehicles are broadly divided into two classes—those in which the motive power is derived from accumulators and those in which a combination of gasolene and electricity is employed, the latter being often called gasolene-electrics. The term "accumobile" has been applied in Europe to the former type of electric car, which is most common in use, but this name has not met with favor in the United States —nor is it generally used in Europe, for that matter. Its formation is defective from the etymological point of view, and it is probably destined to be short lived. See Electric Cars, Motor Car, and Principle of the Motor (under Electric Motor).

Electromotive Force—The cause of the establishment and maintenance of a difference of potential, and therefore of a flow of current, between any two points. Generally referred to as E. M. F.

Electromotor—An electric motor, as distinguished from a dynamo.

Electron—The charge of electricity borne by an atom, also called the atomic charge. Recent experiments seem to show that this charge, the electron, can be separated from the atom and that it is the agent by which electrolysis and the electric discharge in a vacuum are carried on.

Electrostatics—The branch of electrical science which treats of the properties and effects of static or frictional electricity, as distinguished from electricity in motion or current electricity.

Electrostatic Stress or Force—The force exerted near any electrically charged body on other charges which are in the vicinity of the first.

Electrum—A term applied to amber (Greek "electron"). also to an alloy resembling silver. It is a very old term for an alloy of gold or silver, having been so used by the ancient Romans.

Elliptic Springs—See under Springs.

Element—One of the simplest constituents or parts of which anything consists. In chemistry, one of the eighty-odd substances which hitherto have resisted resolution by chemical analysis.

Elongation—The act of stretching or lengthening, as the elongation of a wire.

Emergencies, Conduct in—See under Driving.

Emergency Brake—A brake for use on a motor vehicle in sudden exigencies, so as to secure a quick stop; a reserve brake. Emergency brakes should be frequently tested and every driver should accustom himself to their use.

Emergency Exit, Magneto—See under Ignition.

Emery—A variety of corundum distinguished for its extreme hardness. A very necessary article of equipment for every automobilist, as it is used for grinding a smooth face on all valves, cocks, etc., to make a tight joint.

When pure, emery consists of alumina with slight traces of various metallic oxids. In general, however, it is not pure corundum but is mechanically mixed with more or less magnetite or hematite. For use the stone is usually crushed to a powder of varying degrees of fineness, which is attached as a coating to paper, cloth, wood, etc. The solid stone is sometimes worked into shapes suitable for use.

Emery-board—Paper pulp mixed with emery dust and shaped as desired.

Emery-buff—Same as Emery-wheel.

Emery-cloth—A fabric coated with glue and emery dust and used for polishing and scouring purposes.

Emery-paper—Paper coated with glue and emery dust.

Emery-wheel—A polishing and grinding wheel made of or coated with emery.

E. M. F.—The technical contraction for electro-motive force, used to denote the pressure or voltage of a current. It is the difference of potential between any two given points in an electrical circuit.

Enamel—A process of painting the framework and other metal component parts of a motor car or cycle. The name is wrongly applied, as the process is more of a japanning character than enameling.

Enameled Leather, Cleaning—See under Cleaning.

Enameling—The act or art of laying on enamels. The so-called enameling of leather is usually done by means of varnish or lacquer. True enameling involves vitrification or glazing by heat.

Endothermic—Relating to the absorption of heat. Endothermic bodies are those whose formation from elementary substances is attended with absorption of heat and whose decom-

position liberates heat. Nitroglycerine and other explosives are examples.

End-thrust—The term is usually applied to a shaft which rotates in a bearing and which from some cause is under the action of an axial pressure tending to move the shaft along in the direction of its length. This pressure is the end-thrust. To prevent the lateral play of the shaft which might arise from such pressure, either a thrust bearing or thrust washer is used, or for small end pressures a collar is fixed on the shaft close by the ordinary bearing so as to prevent the shaft from slipping through the bearing endwise.

Energy—The power of doing work; capacity for producing effect upon matter.

The fact that any agent is capable of doing work is usually expressed by saying that it possesses energy, and the quantity of energy it possesses is measured by the amount of work it can do.

The energy possessed by a mass in consequence of having been raised from the ground is commonly distinguished as "energy of position" or "potential energy," and is measured by the product of the force tending to cause motion, into the distance through which the point of application of the force is capable of being displaced in the direction in which the force acts.

The energy possessed by a body in consequence of its velocity is commonly distinguished as "energy of motion" or "kinetic energy," and is measured by half the product of the moving mass into the square of its velocity.

Energy, Correlation of—In physics, correlation of energy or of forces is the term applied to the theory that all the forces of nature—heat, light, electricity, magnetism, chemical affinity and motion—are mutually convertible. Thus the gasolene engine is used to transform the potential chemical energy of gasolene and the oxygen of the air into mechanical energy for the propulsion of an automobile or other purpose. In every such transformation there is a certain loss of useful

energy in useless heat. This loss is called the dissipation or degradation of energy.

Energy, Dissipation of—See under Correlation of Energy above.

Energy, Transformation of—See Correlation of Energy.

Engine—A machine by which some form of motive energy as heat, is converted into work. See Engines below.

Engine Bearings, Adjusting—See under Overhauling.

Engine Brake—See Engine, Retarding with the.

Engine, Care of the —See under Overhauling, Engines, etc.

Engine, Compound—See Compound Engine.

Engine, Diesel—See Cycle, Diesel.

Engine Efficiency—See under Compression.

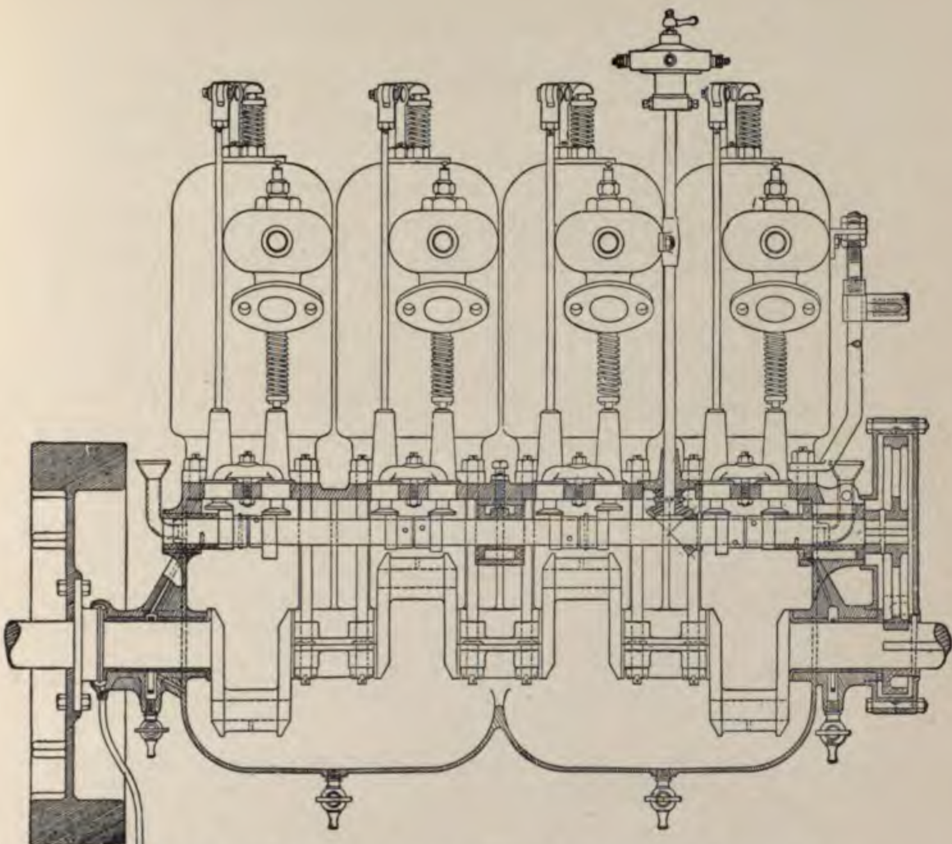
Engine, Explosion—A name commonly but incorrectly given to the internal combustion engine.

Engine Flexibility—The term "flexible" is applied to a motor-car engine which will exert a considerable force when rotating slowly. Of recent years considerable improvement has been obtained in motor cars in this direction:

1. By increasing the number of cylinders.
2. By increasing the flywheel effect.
3. By decreasing the compression.
4. By increasing (automatically) the richness of the gasolene-air mixture at slow speeds.
5. By providing a very full and effective ignition spark.
6. By diminishing the friction in the engine and transmission.
7. By providing more accurate timing as between the cylinders—that is, when we retard the spark it is equally retarded in all cylinders within a narrow margin.

The effect of a flexible engine is greatly assisted by the use of certain types of clutch which allow the engine to rotate rather faster than in proportion to the progress of the car, and so to carry itself over its dead centers.

Engine, Gas—Any engine in which motion is communicated



Longitudinal Section of Engine—The Great Western Automobile.

The Apperson Model "M."

to the piston by the alternate admission and combustion of gas in a closed cylinder.

Engine, Gasolene—An engine in which the fuel employed is gasolene. See Internal Combustion Engine.

Engine Knocking—See under Engines.

Engine, Naphtha—An internal combustion engine using naphtha as fuel.

Engine Power, Loss of—See under Engines.

Engine Pressure—This term is applied to the pressure occurring in the combustion head due to the expansion of the fired charge. It averages about 270 to 300 pounds per square inch.

Engine Protection—Owners of cars who drive them as hard in the winter as in the summer should be provided with an under apron protecting the engine and gearing from mud. For a chain-driven car the apron should reach from beneath the radiator to the countershaft, and as far back as the rear axle on a live axle car. To keep the apron clear of the flywheel or other projections, a light frame of iron can be made and attached to the side members of the car frame. The apron itself should be provided with straps so placed as to secure it without much trouble, and a little examination and measurement will be sufficient to enable the straps to be placed in correct positions.

Engine, Retarding With the—One of the brakes is usually operated by a pedal, and the other by a side lever. In some cars the brake pedal is coupled up to the clutch, so that applying the brake automatically disengages the motor from the driving gear. This is all right in the ordinary way, but in descending very steep hills it is useful to be able to let the car drive the motor through the low gear, thus obtaining additional retarding effect.

This is sometimes accomplished by fitting an additional pedal which acts on the brake only. The side lever should be, and practically always is, provided with a ratchet device, to allow of the brake being held on when the car is left standing.

As both the road wheel brakes are operated from a single lever (foot or hand), a compensating device should be introduced into the connections to insure that each brake shall be applied equally. The compensator should be constructed on the balance beam principle, but sometimes has consisted of a crude arrangement of thick wire cable bending round grooved guides of short radius. This cannot be considered satisfactory.

Engine, Rotary—An engine in which the cylinder revolves upon the piston or the piston in the cylinder; also, a reciprocating engine with a flywheel and crankshaft.

See Motor, Revolving.

Engine Shaft—See Shafts.

Engine Shield—A protection for a motor engine. See Frame.

Engine, Starting the—See under Driving.

Engine, Starting in Cold Weather—See under Cold Weather and Driving.

Engine, Steam—A machine in which heat energy is transformed into mechanical work by the means of steam. See "The Steam Car" under Motor Car.

Engine Valves—See under Valves.

Engineer—One who has the care of and operates an engine, especially a steam-engine.

Engines—For a detailed description of the gasolene engine in common use for automobile purposes see Internal Combustion Engine. Further information may be gathered under the headings, Carbureter, Ignition, Timing, etc.

The engines used on electric cars are described under the heading Motor Car, in the section devoted to "The Electric Car;" also under the separate heading, Electric Motor.

The steam engines in use for automobiles will be found described in the section headed "The Steam Car," under the general heading Motor Car. Also see Steam Cars.

In the paragraphs which follow under this general heading

"Engines," many of the problems arising in connection with automobile engines, especially those of the gasolene variety, are treated of from the standpoint of both early and recent experience.

How to Remove a Broken Screw.

In dismantling an engine sometimes a screw or stud will break off short, and difficulty will be experienced in removing it. Generally there is not enough projecting metal to enable a good grip to be obtained with pliers, so that a saw cut has to be made in it for a screwdriver. If there is not even enough metal for this, a hole should be drilled vertically in the screw, and the triangular or rectangular tang of a file inserted, which will generally obtain sufficient hold to enable the screw to be removed. If a left-hand flat drill is used—that is, one cutting counter-clockwise—this alone will often be sufficient to bring out the screw. In extreme cases, an alternative is to drill a hole vertically in the screw as before, to tap the hole with a left-hand thread, and screw it in with a left-hand screw, which, on being screwed up tight, draws out the right-hand stud.

Lengthening a Valve Stem.

In course of time, a valve stem that has been long in commission will shorten, owing to the hammering action of the tappet against its lower end. This shortening means incorrect opening and closing of the valve, both as regards the instant at which these take place and the lift. If the valve is an exhaust valve, loss of power ensues, and the symptoms of overheating are set up. The proper cause is frequently overlooked and much money is spent on having the pump and water circulation examined and attended to. The valve stem can be lengthened in a very simple manner, which saves the expense of fitting a new valve. The foot of the valve stem is softened, if necessary, and a small hole drilled axially in it, and tapped. Into this hole is screwed a cheese-head screw, which is filed down to the same size as the valve stem, and of sufficient length to take up as much of the clearance as necessary.

Another method is as follows: Braze a piece of tool steel to the end of the valve stem; before this has had time to cool, plunge in water to harden it, and grind it to the correct length. This makes a splendid job—in fact, better than new, as the end of the valve stem has a perfectly hard surface, and wears much longer. Also there are fewer loose parts, and consequently less wear than in the method suggested above. An old and attenuated valve treated in this manner will work quite as well as a new valve.

A Cause of Deposit upon Piston Heads.

Many owners have been interested in examining the deposits formed on the piston and cylinder heads, and have been astonished to find that, in many cases, these deposits contained a far larger proportion of mineral matter than of carbon. In one case an owner used five gallons of a certain oil, which only contained mineral matter equal to 0.01 per cent, and yet, after he had finished the whole five gallons, he collected from his cylinders almost one ounce of so-called carbonaceous deposit, which amount did not represent the whole of the deposit, as a complete collection was practically impossible. Now, this one ounce of deposit, on analysis, showed the presence of just over 0.75 ounce of mineral matter, largely of a silicious composition, whereas 0.01 per cent of five gallons of the oil only means 0.07 ounce—therefore the difference, that is, 0.68 ounce of mineral matter, must have come from some external source. The only conclusion that can be arrived at is that some of the dust, which necessarily must be drawn into the cylinders at each suction stroke, is caught by the film of oil as on a flypaper, and so gradually accumulates, forming, with the help of the carbonization which also occurs, a hard cake. Further, it has been found that in the summer this proportion of mineral matter to carbon is greater than in the winter, when there is less dust. And, further, it is noticeable that with an oil that carbonizes badly, the proportion of carbon is much higher in comparison with that of mineral matter.

A Cure for Deposits on Piston.

In another case, an owner coated the top of his engine piston and the combustion chamber (after thoroughly cleaning them) with ordinary plumbago mixed into a paste with gasolene. He ran the car over 9,000 miles, and on taking down the engine found no deposit.

Overheating: Its Causes.

To a novice in motor matters, the overheating of the engine is sometimes the cause of a lot of trouble, either to the driver himself or to the engine. In the first place, the degree of heat which the cylinder attains, together with certain of the water pipes leading thereto, is a source of wonderment and anxiety to the new owner of the car. On the other hand, he may have a little of that knowledge which is proverbially a dangerous thing, and, knowing that the power of the engine is derived from the explosive combustion of a gas drawn into and compressed in the cylinder, he naturally knows that heat is thereby generated, and so long as the heat is there, he is regardless of the consequences. Overheating is attributable to one of the following causes:

1. No water in the tank or circulatory system.
2. Failure of the pump, where used, to act.
3. Air-lock in the water pipes, preventing circulation. This is also liable to happen with the thermosyphon or natural circulation type.
4. Insufficient radiation surface.
5. Using too rich a mixture.
6. Habitually running the engine with the accelerator up, even when the vehicle is traveling at a slow speed.
7. Ignition point too much retarded.
8. Insufficient lubrication.
9. Choking by dust of the gauze (if used) over the main air intake of the carbureter.
10. Wear of the rear wheel bearings, disturbing the relative positions of the brake-shoes and the brake-drums, so causing constant friction.

Certain of the foregoing items also refer to air-cooled motors, particularly Nos. 4 and 5.

1. No Water in the Tank or Circulatory System.—Dealing with the causes in the order given, we find the effect of the first is very quickly to overheat the engine, usually bringing about the burning of the lubricating oil, which is the first indication given of the overheating. This, however, only lasts for a few minutes, and immediately after the engine has been started. Later, a squeaking may be heard, and if the engine is not at once stopped, the inevitable result will be the piston seizing or sticking in the cylinder, thereby causing considerable trouble, and very often serious damage. If it is found that the water has been drained from the circulatory system, and the engine has been unwittingly started up, the latter must be allowed to get quite cold before any water is put in, or at least as cool as the hand can comfortably bear when pressed hard up against the cylinder head. If the water is put in and the temperature is higher than this, the cylinder jacket and the cylinder itself are very liable to fracture; in fact, if cold water is put into the engine in its highest degree of heat, fracture is certain to follow.

2. Failure of the Pump to Act.—This does not usually involve very great risks, as there is invariably some water left in the cylinder jacket, and before this is finally evaporated, overheating is distinctly noticeable as being the cause of a gradual loss of power in the engine. If one has reason to suspect the pump is not working up to its proper state of efficiency it is well to test the circulation by squeezing one of the rubber hose connections on the delivery side of the pump, or to watch the return pipe in the cylinder lead to the tank, and see if the water is flowing from there. To guard against these risks it is always advisable to fix a water circulation indicator —a little instrument which, while inexpensive, is the greatest safeguard one can have against pump troubles.

3. Air-lock in the Water Pipes.—An air-lock in the water circulation is a very troublesome thing, and one which will trouble the amateur perhaps more than anything else in con-

nection with water-cooling. There are several ways in which this air-lock, or air-pocket, may be formed. By air-lock it is understood that air has been drawn into the water pipes, and forms a complete cushion between two bodies of water, which effectually prevents its flowing. One of the most frequent causes of forming an air-lock is putting a fresh supply of water into the tank when there is a small amount of water running in the pipes which are below the level of the tank. The water rushing into these pipes prevents the air escaping, and thus the air-lock is formed. To prevent this, if there is a small amount of water left in the radiators and connecting pipes to drain it completely away, put in fresh water, allowing the drain-cock to remain open until this flows through. By this procedure the air will, of course, be driven out of the pipes, escaping through the drain-cock by the force of the water behind it.

4. Insufficient Radiation Surface.—This is an inherent constructional defect, but is not always the case, as there are instances where a larger engine has been put into a car without any addition being made to the radiators. Therefore, if one is increasing the power of the motor, the size of the radiators should always be increased in proportion to the increase of the power. The makers of one of the most effective radiators give the length of radiator required as 7 feet per horse-power, that is, with the large diameter single-tube type. With multitubular radiators, the length is about 15 to 20 inches per horse-power.

5. The Use of Too Rich a Mixture.—This is always followed by an exceedingly foul exhaust; but as one can only ascertain that this is the case when the car is standing still, one should set the air adjustment to suit the atmospheric conditions before actually running the vehicle. In changeable climates, atmospheric conditions may alter to such an extent as to cause what was originally a good mixture to become too rich in gasolene, so that the engine may suffer from overheating from this cause without the user suspecting it until the

loss of power is noticeable. Remedy: Provided the circulation is correct, see that the mixture is not too rich.

6. Habitually Running the Engine with the Accelerator Up.—The habit which many drivers fall into of driving the engine continually at its top speed is one to be deprecated. The effect is increased wear upon the piston and cylinder, owing to the increase in piston speed. Supposing the normal speed of the engine to be 1,000 revolutions per minute, accelerating to 1,200 r. p. m. means that, if the engine is habitually run at 1,200 r. p. m., it makes no less than 12,000 revolutions per hour more than it is intended to do. Acceleration is provided to give an increase of power when required for short intervals. There are, of course, some engines which are designed to run at 1,500 r. p. m., but in these the water circulation is accelerated, and extra special attention is given to lubrication to prevent overheating.

7. Ignition not Sufficiently Advanced.—The mixture is burnt slower and the flame is longer in contact with valves, combustion chamber and piston head. This causes overheating and loss of power. The remedy is to keep the ignition point advanced to a position just short of knocking except when it is desired to run the engine dead slow.

8. Insufficient Lubrication.—The results in this case are similar to those of poor circulation, namely, loss of power. A seized piston with all its attendant evils may result from want of sufficient oil.

9. Choking of Gauze Covering of the Air Intake.—If a wire gauze is used to pass the main supply of air through to the carburetor, in dusty weather this is rather likely to get partially choked up, and thus as less air is allowed through the gauze the suction on the gasolene jet is increased, and therefore a much richer mixture is obtained. The remedy for this is to wash the gauze through with gasolene to remove the dust.

10. Wear of the Rear Wheel Bearings, Disturbing the Relative Positions of the Brake Shoes and Drums.—A more probable cause of overheating is, however, that after a time, more

particularly on live axle cars fitted with internal expanding brakes, a certain amount of wear takes place on the rear wheel bearings, and this allows the wheel to be forced upward relative to the axle sleeve, and since the brake segments are carried on a bracket secured to the sleeve, it follows that the lower portion of the brake segment is lower relatively to the brake-drum. Thus it commences to rub, and consequently the engine has to work as though it were always driving the car up an incline. The same thing applies to external brakes, which may be fitted without any device for removing the brake blocks or bands from contact with the drums when the brakes are supposed to be taken off. All these bands or blocks should be properly fitted with springs and stops, so that they may be automatically and entirely removed from the brake-drum when the braking action is released by the driver.

Precautions Against Overheating.

Overheating in a motor is a serious circumstance, and every precaution should be taken to guard against it, as harm will result unless immediately attended to. The chief symptoms are a loss of power, accompanied by harsh running, steam rising from the cooling water, and premature ignition resulting in a knock in the motor. The causes of overheating may be restated as any one of the following circumstances:

1. Loss of cooling water.
2. Want of oil or imperfect lubrication.
3. Racing the motor for long periods.
4. Continued driving on a low gear with the ignition forward and a large volume of mixture.

This, of course, applies to motors without governors and is equal to racing a governed engine. The remedies are (1) to see that the pump, if used, is working properly, and that no leakage is taking place at any part of the system, and that the water tank is filled and replenished as often as required; (2) fill up the lubricators and see they are working properly, and occasionally wash out the oil tank and pipes with kerosene; keep all the joints tight and free from leakages; (3) refrain

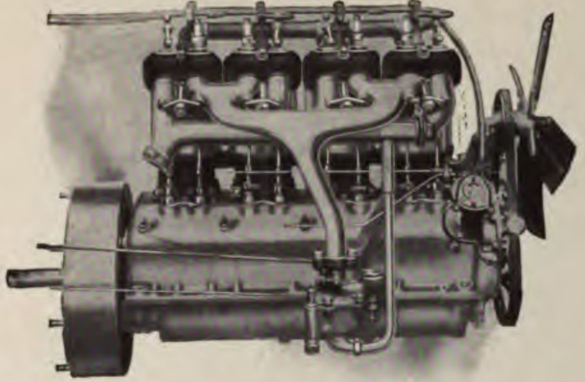
from racing the motor unless it is absolutely necessary, such as, for instance, starting on a bad hill; (4) drive on the highest gear you conveniently can, with the throttle as little open as possible, and the sparking advanced. The result is economy in fuel, easy running, and a large reserve of power without changing speed.

Piston Working Dry.

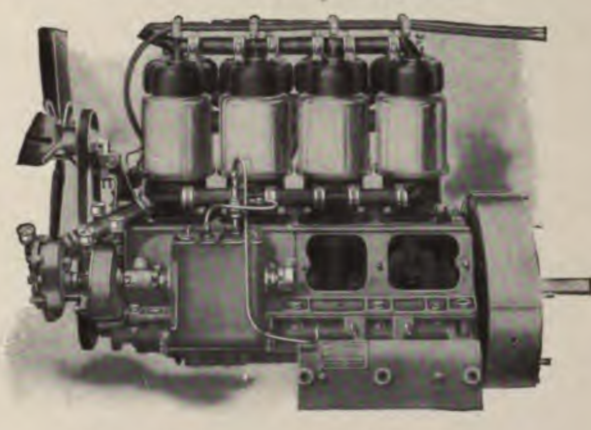
If the engine becomes overheated, a knocking will in all probability be heard. This conveys the impression that the piston pin is loose in the piston, or in its bearing in the connecting rod end, or that the big end brasses (bushings) embracing the crank require adjustment. The knocking is often actually due to the piston working dry in the cylinder, and unless an excessive supply of lubricating oil is at once given and the engine allowed to cool down, there is every possibility that the piston will seize in the cylinder and score it, when an expensive renewal of piston or cylinder, or probably both, will have to be made. Never run the engine to its utmost capacity for a longer period than is absolutely necessary, unless you wish to shorten its life considerably. When the car is on the level or running downhill, the speed desired can be obtained by judiciously advancing the spark and reducing the gas by means of the throttle valve. This at the same time gives economical running.

Fan Belts.

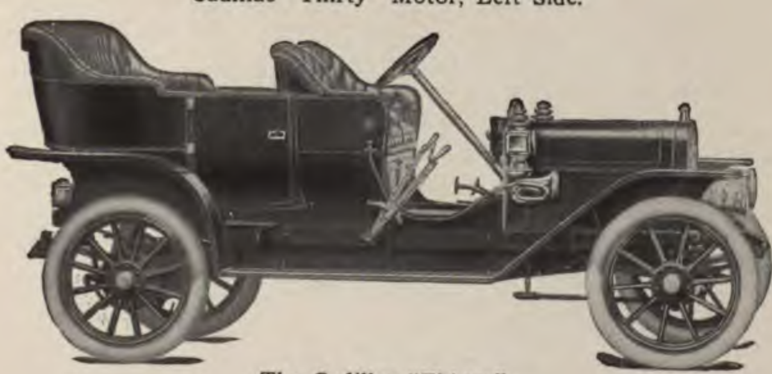
Those whose cars are fitted with fan-cooled radiators with belt-driven fans should give a little attention now and then to the belt, and see that it has not become so loose that there is a good deal of slip, so that the fan does not rotate so rapidly, and consequently does not draw as much air through the radiator as when it was tighter. To run these fans at high rates of speed requires more power than is generally imagined, and if the belt becomes over slack there is undoubtedly the slip we have mentioned, particularly with round belts on V-rimmed pulleys. This was brought home to one owner by the fact that upon several occasions his engine and cooling water seemed hot-



Cadillac "Thirty" Motor, Right Side.



Cadillac "Thirty" Motor, Left Side.



The Cadillac "Thirty."

ter after a long run than of yore, and he began to suspect either a failing pump or some stoppage in the water circulation. Noticing, however, that the fan belt was very slack, he tightened it, with the result that a certain hissing sound, which had before proceeded from the bonnet when the car was standing, returned and after subsequent runs the engine and the water were as cool as formerly. But for happening to tighten the belt he might have gone to the trouble and expense of dismounting the pump and cleaning out the water conduits.

The Exhaust Cut-out.

Some mufflers are badly designed, and therefore cause an excessive loss of power, owing to the back pressure caused by the exhaust gases being unable to escape freely. Some are worse than others, the new however being, as a rule, better than the old. In this case it is a very simple matter to fit an exhaust cut-out to a car, while the difference in "life" from the engine is very great. There are many ways of doing it, of course, but the simplest method is to fit a flap door to an opening in the exhaust pipe in front of the muffler, normally keeping the door closed by means of a spiral spring. A wire from this door to the dashboard would provide a means of opening. In many cars the fitting of a cut-out would prove an inestimable improvement as regards power, while the difference in life of the exhaust valves would be most marked. Where a cut-out is fitted, an obstructed muffler giving absolute quietude is no objection, even at the expense of considerable back pressure. It will be found that the noise with the cut-out open is only appreciable when the engine is picking up and working hard. When running at any set speed, the sound of the exhaust is not so audible as one would imagine. It is necessary to confine the use of the cut-out to the open country, where it will not cause annoyance to others.

Governors: Their Use and Action.

As these paragraphs are primarily written for novices, we make no excuse for explaining in detail the action of the gov-

ernors generally used in motor-vehicle engines today. Such governors are on the centrifugal principle. It is one of the natural laws that a swiftly rotating body tends to fly from its center. This action is taken advantage of, and the centrifugal governor constructed in a very simple manner. As a rule it will be found that this mechanism is mounted upon the camshaft or layshaft of the engine, though in one or two instances it is attached to the forward end of the engine crankshaft. Whichever shaft it is put upon it will be found that it consists essentially of two arms at opposite sides of the shaft, which are hinged to a lug firmly keyed to the shaft. These arms carry weights at their opposite ends, and are connected by links to a sleeve, which is free to slide on the shaft. The centrifugal action of the weights is counteracted by means of a spring, the tension of which may be so regulated that the governor may be set to function at any predetermined time. So that when the centrifugal force overcomes the resistance of the spring the governing of the engine begins to take place. There are various forms of the centrifugal governor, but all function in precisely the same manner.

Governing on the Inlet.

In the majority of governed engines of today the governor acts upon a valve placed in the induction or inlet pipe. This valve regulates the amount of gaseous mixture which is allowed to pass through to the cylinders. Many of these throttle valves take the form of a butterfly valve, consisting of a disk, which will close the induction pipe completely when placed at a right angle to the center line of the tube, but which, when in its normal position, that is, horizontal with the tube, causes practically no resistance to the passage of the gas, excepting that which is offered by the thickness of the disk and the spindle upon which it turns. This spindle is fitted with an arm on its outer end, and is connected to the governor sleeve by suitable connections, so that when the governor has overcome the first resisting pressure of the spring it gradually closes the valve. As the engine speed increases, the governor

still further compresses the spring, and in so doing closes the throttle valve by bringing the disk more toward a right angle position in the inlet pipe. It will be seen that this is a very simple and effective method of reducing the speed of the engine, preventing it from overracing by simply reducing the volume of mixture passed to the cylinder.

Other methods of reducing the cylinder charge are: (1) By means of one circular chamber working within another, the inner chamber having two orifices, which correspond with those in the outer chamber, which is inserted in the inlet pipe. By revolving the inner chamber the apertures are varied by the inner one reducing their area. (2) Another means is by inserting a chamber in the inlet pipe, in which works a mushroom type valve, the lifting of which regulates the amount of mixture passed.

The Function of the Governor.

The ideal conditions for the working of an internal combustion engine are those in which the speed of the engine shall be such as shall develop just sufficient power to enable it to run smoothly, and at its most efficient speed. When the speed of the engine is reduced, the power decreases in relation to the reduction in speed. In like manner, power increases with the increase of the speed of the engine. It is to prevent the production of more power than is actually needed for the propulsion of a vehicle that the governor is fitted. When the car is running on level ground with a good surface, the engine is working in an economical manner, because the governor only allows of the admission of sufficient gaseous mixture into the cylinders to produce the amount of work that the road conditions call for. So that when the speed of the vehicle, and with it the engine, is reduced, as when surmounting grades, the governor opens wider and admits more mixture, thus keeping up the speed of the engine.

Governor Setting.

Persistent hunting or racing of the engine is by no means an infrequent source of unsatisfactory running, militating

against comfort, economy and flexibility. The matter is one which it is difficult to remedy, in that the trouble commonly lies in the tension of the governor springs being either too great or too small. Springs with small variations in tension are difficult to obtain, at least in a graduated ascending scale of strengths, and consequently it is found that, whereas the original spring permitted the governor to act unduly at the slightest speed variation, the new spring practically obliterates the action of the governor, and the engine is difficult to control, although the difference in the two springs may be apparently very small. In adjusting the governor springs, one has, of course, to vary the adjustment according to the location of the spring. In some engines the springs are set across the points of the governor weights and revolve with them. With other patterns the spring is set between a sliding collar and a top on the shaft, and there are various other methods.

Trouble with Distorted or Sticking Valves.

There are times when misfiring takes place at intervals and the ignition appears to be at fault, but it may prove to be that owing to overheating the exhaust valve has become distorted or pitted on its seat, or the stem is slightly binding in its guide. The symptoms are very similar. In the first place it will require carefully truing up in a light lathe, care being taken to preserve the correct angle of the valve seating, and to keep it absolutely true and straight with the stem, the slightest eccentricity of one with the other being fatal to the running of the motor. If pitted badly it will also require turning in the lathe and grinding-in afterwards, or if slightly pitted, grinding-in only will suffice, fine flour of emery and common lubricating oil only being required. To cure the sticking stem, smoothen it up with fine emery cloth to slightly reduce the diameter and remove the roughness, oil slightly, and replace after grinding in the seat. If the valve stem becomes slightly bent in any way it is sure to stick. It is better to put in a new true valve at once, if the old one cannot be made perfectly true.

A Cure for Engine Knocking.

We will take a typical case of an engine which, on hills, appeared suddenly to lose its power, and when the spark was very slightly advanced to develop a very bad knocking. When the engine was stopped it was quite impossible to distinguish any loose parts or loss of compression in either the rings or the valves; all seemed perfect. However, a point was noticed which might account for the loss of power when on hills. The exhaust valve stem had very little clearance between its bottom and the valve tappet, and on carefully noticing the engine while working it was discovered that this valve stem so increased in length with the heat that it just touched the valve tappet when the exhaust valve was near its seating; hence it could not close properly under the action of the exhaust valve spring. Upon slightly filing the tappet so as to give a little more clearance between the bottom of the valve stem and the tappet, the engine was found to pull as well as ever it did, and, furthermore, the knock had entirely ceased. Evidently this proved that the knock had been due to the slight escape past the exhaust valve on the explosion stroke, owing to the tappet not allowing it to come dead on to its seating when the valve was heated. This will be useful information to others who have experienced a like trouble.

Knocking in the Engine: A New Cause.

The question as to what is the cause of a knocking noise in an engine is frequently asked. The causes are usually ascribed to loose bearings or an unlubricated piston, and in the majority of cases one of these is the true fact of the case, but occasionally the prescribed remedies are of no avail, and the cause has to be looked for in another direction. A case is reported of an engine which developed an incurable knock, and the owner states that very careful examination disclosed the fact that the crankshaft had twisted slightly, this, of course, being the cause of the knock. This, however, is a cause which should only be suspected when all others have been exhausted.

Another Cause.

From time to time one comes across or hears of an engine which has developed a mysterious knock, for which no advanced ignition, or play in the bearings, big end, or gudgeon pin can be brought to account. In all probability no such shortcomings are at the bottom of that irritating tapping, but on the piston top and walls of the combustion chamber there is a thickish deposit of carbon. Clean this all off, and it is probable that the knock will disappear. In the case of such an unaccountable development it is easier to begin by clearing off the deposit if the heads are separate from the cylinder.

Squeaking Noises.

Should an engine develop any peculiar squeaking noises, it is as well to look to the seat of the inlet valve and to the stem of the exhaust valve. The latter is a source of many squeaking noises.

Loss of Engine Power.

When compression is good and ignition right, but at the same time the engine will not pull up to its form, there is very little doubt that the carbureter is at fault. When running light, that is, out of gear, the engine will turn splendidly. It may obey the throttle or accelerator instantly and show every evidence of life, and yet as soon as it is driving the car it will fail miserably directly there is any work to do. The reason the engine runs well when there is no load is because it has practically nothing to overcome except its own weight and friction, so that a very small supply of explosive mixture will keep it running at racing speed. In a recent case of this kind the autoist, after trying everything he could think of, found that the loss of power was due to the rod which worked the throttle being loose. He had never detected that the throttle, when apparently wide open, so far as the positions of the hand lever and the governor lever were concerned, was not really giving full aperture, and consequently the engine was being starved. In this case, not only had a great many engine adjustments been made, but the carbureter had been examined,

and the reason the cause was not detected was because the rod which operated the throttle was close up against the frame, and almost out of sight. As there are many cars in which these rods, for convenience, are placed well out of the way, it is an experience which should not be forgotten.

Overheated Bearings.

When the main bearings and big end of the connecting rod bushings are scraped in when new or after running some considerable time, it is necessary to take up the wear and rescrape the bushings after a greater or less period. On again running the motor, it is sometimes found that there is a tendency to overheat the bearings, and liberal supplies of oil must be given to avoid binding. It will be found that if after scraping in the bushing, and before putting on lubricating oil, the wearing surfaces are well rubbed with flaked graphite, they will run much sweeter and will not have the same tendency to heat up. When examined under a microscope the bushings appear to be porous, and made up of more or less sharp crystals. The effect of the graphite appears to be that the pores are filled up with this unctuous material and a smooth surface formed, friction thus being materially reduced.

Inlet Valve Key in Cylinder.

The inlet valve key of an automatic inlet valve, although held in place by a special washer, and even by the spring, sometimes falls inside a cylinder, especially when the motor is over-run in descending a hill at a rapid pace. In a case of this kind, the inlet valve is returned so rapidly to its seat by the compression that it closes more quickly than the spring can expand; the key then flies out, and may fall inside the cylinder. The question is, what is the best thing to do when this takes place in a single-cylinder engine? If there is no hurry, the water can be let out of the tank, the pipes detached, and the cylinder taken off. This is the proper way, no doubt, but it is a roundabout method. A quicker way is to push the car to the side of the road, so that the engine is inclined towards the exhaust valve side, and undo the gas pipe. Now

turn the starting handle rapidly, and the key will probably be thrown on to the top of the exhaust valve. Another way, and a less fatiguing one, is to replace the lost key with another and start the motor up slowly, leaving the car inclined as before. After the engine has run a minute or two, detach the pipe, and in all probability the key will be found on the top of the exhaust valve, provided the car is sufficiently tilted. On no account must the key be left in the cylinder. By constant hammering against the head of the piston or the top of the cylinder, the key will be reduced to a ball, and may eventually find its way out down the exhaust pipe and into the muffler, but as it is hardened, it may do considerable damage to the cylinder walls before this takes place. In the case of a two-cylinder engine the operation is easier. All that is required is to detach the sparking plug from the cylinder in which the key is lost, and start up the engine. In a very short time the key will most likely be thrown out through the sparking plug hole. The car must be left in the inclined position.

Hissing Noises.

If an engine develops a peculiar whistling sound, which is accompanied by a noticeable loss of power, any joints which may be made in the cylinder head should be tested for tightness. Such joints may be found at the sparking plug or tappet in low-tension magneto-fired engines, the caps which cover the valves and compression relief cocks. The best way to test for leakage—provided it cannot be found by feeling with the hand—is to run a little lubricating oil round the joints to be tested, and then run the engine. Any escape will, of course, form bubbles in the oil, and so the point of escape is located.

A further cause, which might result in considerable damage being done, and which is very difficult to locate, is that of an open, or lost, oil drain-cock in the crank chamber. As this is generally out of sight, it is similarly out of mind, and in consequence a driver may continue on his way until he is pulled up by a seized piston. A blown exhaust-pipe joint or loosened nuts on the exhaust system are usually accompanied by a

sharp hissing or crackling, and can generally be put right in a few minutes.

On Fitting Piston Rings: Signs of Bad Rings.

A loss of compression means a loss of power. To discover the cause of this loss of power is one of those things which often baffle the motorist, even though he has got through the novitiate stage. Loss of compression is liable to be caused by several things—for instance, leaky inlet and exhaust valves, a badly-fitting combustion head (in cases where the head is separate from the cylinder barrel), or by badly-fitting piston rings. It is with these latter that we will deal at the present time. Supposing that we have a single-cylinder engine, whose compression is bad; the valves have been taken out and ground in to a perfect fit (see Overhauling); the joint at the combustion head has been examined, and there is no doubt that this is perfect, but still the compression is bad. This points to the fact that the piston rings need some attention. It is therefore necessary to disconnect the cylinder entirely from the crank chamber, so that when the former is removed, it leaves the piston attached to its connecting rod. Care should be exercised when removing the cylinder not to disturb the piston rings, but to note the relative position of the slots in these as the cylinder comes off. If the slots in the rings are approximately in line, this in itself is sufficient to cause a loss of compression without the rings being absolutely bad. The internal combustion motor, as a rule, is fitted with three piston rings, and the slots of these should be equidistant from one another, to insure there being no leakage past them.

The Cylinder Removed.

The cylinder now being removed, we are enabled to examine carefully the piston and its rings, and provided that the slots in the rings have not been opposite to one another, we now have to look for the cause of the trouble. If the rings are bad, the points at which the gas has been escaping by the piston and rings will be denoted by a burnt or brown or roughened surface on the polished surface of the piston, and the rings.

It will frequently be found that these places occur near the slots in the rings, these being quite discolored for perhaps a quarter of an inch from each end of the slot; or it may be that one ring has not been really true when it was first put in, and it has allowed the gas to escape in small quantities at first. Continued compression of the gas has caused an increasing escape, until quite a large area of escape has been created. This, as in the other case, will be noted by the discoloring of the ring.

The Removal of the Rings.

Having discovered the bad ring or rings, their removal is the next question with which we have to deal. The rings being bad, it is practically immaterial whether they are broken or not in the process of their removal, but we would advise those who are fitting new rings for the first time to be very careful in the removal, as the experience thus gained will be of benefit to them in replacing the new rings. Two pairs of hands are really required to carry out the operation successfully, though with a little extra caution and trouble it may be equally efficiently carried out by one person. The first thing to do is to open the ring by springing the ends apart at the slot, and this is best done by means of two implements; practically anything will do that will fit into the groove of the piston. These being inserted into the slot in the ring, they are gently forced apart, so that the ring is expanded. Then, by inserting a finger or fingers between the implement the left hand can be passed round to the opposite side of the cylinder, and the ring lifted, so that it rests upon the edge of the groove. It can then be forced gently off the piston. In removing the middle ring, care will have to be taken, or the ring will drop into the groove vacated by the top ring. If this does happen, it will, of course, have to be removed in the manner before mentioned. In many instances, the bottom ring can be slid over the trunk of the piston and sprung open sufficiently to pass over the connecting rod, thus saving the possibility of its falling into the two grooves above, and the subsequent trouble of its removal.

Form of Piston Ring.

When the rings are removed, it may be noticed that they are not of the same thickness all the way round, but that the bore of the ring is slightly eccentric, and the slot in the ring is placed at the thinnest part. These rings, it may be stated, are turned from fine gray cast-iron, this having proved, after many years of experimenting, to be the best metal from which such rings can be constructed. This form is given to the ring so as to give it a certain amount of spring, by means of which it shall of its own accord keep in close contact with the walls of the cylinder.

It is not without interest to know how these rings are made, and, therefore, we give a brief resumé of their construction: A concentric ring is turned off a suitable iron casting somewhat larger than the finished size required. The rings thus obtained are split open at any point, and a given length is taken from the circle. They are then closed together by being forced into a piece of tube, in which state they, of course, form an untrue circle. The tube with the rings, in which all the slots are in a line, is passed on to a bar provided with a shoulder at one end and a large flange or washer with lock-nuts at the other end. The flange is put over a bar or mandrel, and the lock-nuts tightened up, so that the rings are held firmly in position. The tube which has served to hold the rings together is then knocked off, and the rings are turned down to the required size, this process leaving them thinner on the one side than on the other.

Preparations for Fitting.

The tools required for fitting a piston ring are a large sheet of emery cloth—No. 1 grade, but not coarser—a thin, fine, flat file, a pair of lead clips, and a vise. After scraping any deposit of burnt oil which may have accumulated in the grooves of the piston, three rings are selected—a suitable one for each grove. The ring should be turned all round its circumference for the groove into which it is to fit. This, of course, can be done without springing it over the piston. The

ring should just fit easily, but not too much so, and on no account should one which is at all tight in its groove be fitted in that condition. It should be laid flat upon the piece of emery cloth and carefully rubbed down until it fits the groove it is to occupy. It is advisable to fit each ring individually, in order to insure its not eventually finding a position in another groove.

We next have to turn attention to fitting the ring into the cylinder itself. The ring should be pushed at least an inch up the cylinder, and should be sprung outward with the finger. If the ring is not of correct diameter, but slightly larger than the cylinder bore, this will be shown at the angular slot by the edges of the ring being out of line. Now take the fine file and carefully remove from the slot a small quantity of metal, being particularly careful to keep the edges of the slot parallel. Sufficient metal must be removed, little by little, until the edges of the ring come into line. The ring is now ready to place in its position upon the piston.

When fitting new rings a slight space should be left between the ends of the ring, otherwise, when the ring gets hot, the expansion may cause the ends to abut and to jam in the cylinder; this jamming being sometimes sufficient to stop the engine. This defect is liable to puzzle the novice badly, as the moment the engine stops the heat passes from the rings into the surrounding metal, and the engine becomes quite free.

Replacing the Rings.

Very great care is necessary in placing the rings in position upon the piston, as, owing to the nature of the metal, they are very liable to break, and this seems to be more the case with new rings than with old ones. It is probably accounted for by the fact that the heat to which they have been subjected while running has tended to make them more springy. The bottom ring should be placed in position first, and it may be possible to open this sufficiently to pass it over the connecting rod. If this is not the case, it must be passed

over from the top of the piston, and by a little careful maneuvering and taking it down over the two top grooves a little skew-wise it may be dropped into the bottom groove without trouble. The middle and top rings may then be put into position. A warning note should be given that it will be found more troublesome if the top ring is put in first, trusting to put in the second and third ring over it, than the method just detailed. It will be very apparent if one thinks for a moment that it would be difficult to spring the top ring close in and at the same time pass another ring over it. The inexperienced man has often been seen to attempt this method, but eventually to give it up, as the other method is far more expeditious and satisfactory.

Replacing the Cylinder.

We are now ready to replace the cylinder, but before doing this the slots in the piston rings must be placed at points equidistant from one another, and care should be exercised that they maintain this position. Nearly every cylinder is slightly bell-mouthed at its bottom end, and this is done chiefly to facilitate the insertion of the piston and its rings. This, again, is really an operation which demands two pairs of hands—one person to drop the cylinder into position, and the other to close the rings in as they enter the cylinder. Single-handed, this is a somewhat difficult operation, and is likely to be attended with a shifting of the piston rings, so that one is never really satisfied that the slots in the rings are in their correct position. The cylinder being bolted down to the crank chamber and all the connections made, a dose of new clean lubricating oil should be inserted in the crank chamber and the motor started up.

On first running, it will be noticed that the compression is very bad indeed, which to the novice is a very uncomfortable result, for after fitting new tight rings he naturally expects at the outset to find a very high compression, and the motor difficult to turn in starting up. It must be remembered that the surfaces of the rings when new are in a rough condition

on their face, and that they do not attain their best form until they have assumed the glass-like face which may be noticed upon the inside of the cylinder and upon the greater portion of the old rings. This surface can only be obtained by working, and, therefore, it is advisable to run the motor for some time in order to permit of the rings gaining this finished state before the car is actually used upon the road. It is advisable, too, when running the piston rings in to over-lubricate the engine slightly, and to renew the charge at frequent intervals. Supposing that we work the motor for two or three hours by itself, it will still perhaps take thirty or forty miles on the road before the engine picks up its full power. If the rings have been properly fitted and the engine kept well lubricated, many hundreds of miles—perhaps running into several thousands—may be covered before the engine will require a new set of piston rings.

Side Lights on Piston Rings.

It may appear curious to some that cast-iron should be the best metal from which to make piston rings. As we before mentioned, many experiments have been made from the time engines first came into use until the present day, and they are still being continued to find a better metal for the purpose. Hundreds of valid patents on piston rings are now in existence. All these, of course, do not apply to the internal combustion engine, but cover spring or other piston rings used in steam engines.

Piston ring troubles are less frequent with larger size engines than with the smaller ones. The trouble appears to increase as the size of the engine decreases, so that in this matter a little bicycle motor will give far more trouble than a big four or six cylinder high-powered engine.

Some makers, to prevent the piston rings turning round in their grooves, drill a hole in the slot in the ring, and screw a small peg into the base of the groove. Many existing pistons can be treated in this manner. However, it is not always sat-

isfactory to do so, for there is not always sufficient metal in the piston in which to screw the pegs.

Engines, Multi-cylinder—See Internal Combustion Engine.

Engines, Winter Treatment of—See under Lubrication.

En panne—A felicitous French expression which has no exact equivalent in English. It summarizes the situation when a motor vehicle comes to a stop against the wish of the driver. We describe a similar occurrence by saying that the driver is stranded, that the car has jibbed, has come to a full stop, has broken down, etc., etc.

Entering the Garage—See under Driving.

Epicyclic Gear—A term applied to a train of gearing when the axles of the gear wheels revolve about a common axis, or when one gear wheel revolves round the external or internal circumference of another gear wheel. Also known as Crypto or Epicycloidal Gear, and sometimes erroneously referred to as the Sun-and-Planet system. See Change Speed Gear.

Epicyclic Gear Changing—See under Driving.

Epicycloid—In geometry, a curve generated by a point on the circumference of a circle which rolls upon the convex side of a fixed circle.

Equalizer—A mechanical device on the plan of the lever, to equalize draft, as in the case of hub brakes on a motor-car. See Brakes.

Equilibration—The act of keeping the balance even; equipoise.

Equilibrium—Equality of weight or force; a state of rest produced by the mutual counteraction of two or more forces, as the state of the two ends of a lever or balance when both are charged with equal weight and they maintain an even or level position parallel to the horizon.

Equipment—See Tools, Spare Parts, and Accessories.

The following is briefly given as the "standard equipment" of a modern American 20 horse-power car.

Lamps: Searchlight type of headlights, 7-inch lens mirror.

Gas generator. Oil side lamps, new square type. Rear signal lamp.

Horn: French type of horn with brass tubing.

Tools and Extra Parts: Jack; 4-inch monkey wrench; 10-inch monkey wrench; 4 socket wrenches; 6 engineers' wrenches; hub cap wrench; spanner wrench for ring nuts; long handled wrench for oil pet-cocks; combination pliers; 3-inch screwdriver; valve spring tool; ¾-inch cold chisel; ball-peen hammer; oil can; tire pump; tire tools; tire repair kit; engine valve; extra valve keys; extra anvil for igniter.

Tools and spare parts are carried in and secured to a strong leather bag—portable and convenient, opening out flat and placed in a special metal compartment under tonneau floor.

Erg—In the C. G. S. system, the unit of work done by a force which, acting for one second upon a mass of one gram (15.4 grains troy) produces a velocity of one centimeter (.3937 inch) per second.

Essence—A term used in France to describe motor car spirit (spirit of petroleum). The word will be found stamped in the metal near the filling cap on tanks of French manufacture.

The term "petrol," or motor car spirit, is the one most usually applied in Great Britain and Ireland to the petroleum spirit used in explosive engines. See Gasolene.

Ether, Sulphuric—A very light, volatile and inflammable fluid, produced by the replacement of the hydrogen of organic acids by alcohol radicals. Called also ethyl ether. It is lighter than alcohol and susceptible of great expansion. It has been experimented with as a substitute for gasolene for motor-car engines. Its vapor when mixed with atmospheric air is extremely explosive.

Ethyl Alcohol—The ordinary alcohol containing the radical ethyl, which has never been obtained in its free state. Distinguished from methyl alcohol or wood-spirit.

Evaporation—The act or process of converting or being converted from a solid or liquid state into a vapor or gas. Gasolene evaporates with extreme rapidity.

Evaporation of Electrolyte—See under Battery.

Examination of Cars—See Choice of a Car.

Examination of Engine Parts—See under Overhauling.

Examination of Tires—See under Tires, also under Overhauling.

Examination of Wheels—See under Overhauling.

Excelsior—A kind of stuffing or packing material for seats, etc., consisting of fine curled shavings of wood.

Excitation—In electricity, the disturbance of the electric equilibrium by friction, rise of temperature, contact, etc.

Exhaust—The emission, outflow or escape of the waste steam from a steam-engine or of the waste products of combustion from an internal combustion engine.

The term exhaust is usually applied to the waste products of the charge which have exploded in the combustion chamber of the cylinder, and which are ejected through the exhaust-valve and exhaust-pipe into the muffler, and thence into the open air.

Exhaust-box—See Muffler.

Exhaust Cut-out—See under Engines.

Exhaust Gas—The exhaust gases which are ejected from the cylinder through the exhaust valves.

Exhaust-pipe—The pipe which carries off the exhaust gases from the cylinder.

Exhaust-port—The opening in the combustion chamber through which the waste products of combustion are ejected.

Exhaust Pressure Lubrication—See Lubrication.

Exhaust, Silencing the—See Muffler.

Exhaust-stroke—The stroke of an internal combustion engine during which the exhaust products are driven from the combustion chamber.

Exhaust-valve—See under Valves.

Exhaust Valve, Grinding in—See Overhauling, also Repairs and Adjustments.

Exhaust-valve Lifter—This is a contrivance for holding the exhaust-valve open, and is principally used in motor bicycles, so as to get rid of the compression when the machine has to be pedaled for starting purposes or otherwise. While the valve is open, there is, of course, free ingress and egress for the air, both on the suction and compression stroke, and therefore there is not sufficient suction to open the inlet valve, and no charge is admitted to the combustion chamber.

Exhaust-valve Regulator or Closer—This is a contrivance used in some cars for regulating the extent to which the exhaust valve opens. Its action is to prevent the admission of a full charge to the combustion chamber, and in this manner weaken the explosion. See Governor.

Exhaust-valves, Broken—See under Makeshifts.

Exhaust Whistle or Horn—A whistle attached either to the end of the exhaust pipe or to a by-pass leading from it, and fitted with a valve by means of which the exhaust gases can be directed through the whistle. The valve is operated by a hand or a foot lever by the driver, and coupled up generally by flexible steel cable.

Exhausted Battery—See under Battery.

Exhaustion of Batteries, Apparent—An owner was once puzzled when an engine which had been running exceedingly well began to lose power badly. It would run along all right on the level so long as the conditions were easy, but as soon as a semblance of a hill was encountered, up which it should have romped on its top speed, the gear had to be reduced. He tried the usual remedies without success, and, having switched over to the spare battery and found the running no better, he put in a third, which had only just been charged. The engine at once responded, and perfect running was again the order of the day. Very soon, however, power again fell away. The owner then tested all three batteries, and found they were all over four volts, but the absolutely fresh one was a little higher than the other two. He then investigated the contact breaker, which was of the fiber ring type, with four fixed wipers bearing

upon it. This had been so recently cleaned that it had not struck him to look at it when attempting to remedy the poor running. However, he found that oil had worked up from the engine into the commutator and had practically filled it. He cleaned it out with gasolene, and lightly greased the fiber ring, when the engine ran perfectly on either of the two batteries which had apparently been exhausted. It is therefore evident that the faltering was due to the foreign lubricant in the contact breaker case offering so high a resistance to the current that it would only pass when it was fully up to 4.4; directly it fell below this the engine ran feebly, although not actually misfiring. The resistance of some electrical circuits on motor cars is so high that three two-volt cells coupled in series are almost a necessity, and in some cases are recommended by the makers of the car.

Exothermic—An exothermic compound is one in the formation of which heat is liberated and in the reduction of which to its original constituents heat is absorbed. See Endothermic.

Expander—A taper instrument used for expanding tubes, etc., in position. In the case of boiler tubes the expander forces the tube into intimate connection with the steel plates forming the ends of the boiler, preventing any escape of steam or water.

Expanding Brakes—See under Brakes.

Expanding Clutch—A clutch consisting of a split pulley expanded by means of levers to grip the inner circumference of a surrounding ring. See Clutch.

Expanding Clutch System—See Clutch, under Change Speed Gear.

Expanding Pulley—A device for increasing or decreasing the circumference of a pulley by means of levers, the object being to alter the peripheral speed between two pulleys without affecting the length of belt connecting them.

Expansion—The increase of volume which takes place in the presence of heat.

The power developed by the ignition of the gases in a cylinder is due to their expansion through heat formed during the chemical combination of their several elements.

See Internal Combustion Engine.

Expansion Gear—See under Gear.

Expansion Joint—See under Joint.

Expansion of Solid Tires—See under Tires.

Expansion of Steam, Use of—See under Steam Cars.

Expelling Dirty Oil From Crank Chamber—See under Lubrication.

Expenses—See Cost of Operation and Economy of Motor Cars.

Explosion—The so-called explosion in the cylinder of an internal combustion engine is due to the violent expansion of the gases forming the charge. Strictly speaking, this can hardly be called an explosion, but is often so termed to differentiate it from expansion as in hot air and steam engines.

Under ordinary circumstances the hydrocarbon vapor given off from the fuel used, namely, gasolene, kerosene, alcohol, etc., is inflammable, and only becomes explosive when mixed with a certain proportion of air. This mixture is stable until part or all is raised to a sufficiently high temperature to start combustion. This can be done by some form of ignition—tube, electric, incandescent, etc. (see Ignition), or by carrying preliminary compression to a high degree. Once combustion has been started, the hydrogen and carbon in the fuel combine with the oxygen of the air, causing a very high temperature, and consequently a violent expansion of the gases. The pressure caused by the expansion is used to move the piston.

Explosion Engine—A term used frequently but incorrectly to describe the internal combustion engine.

Explosion in Acetylene Lamp—This is usually due to the match having been applied to the burner too soon after the gas tap has been turned on and before the acetylene has a good velocity through the burner jets.

The explosive mixture is formed when the proper proportions of acetylene gas and air (which found its way in when the lamp was recharged with carbide) are present. This proportion is liable to be reached every time the lamp is first lit after a recharge. The remedy is very simple, and consists of waiting for the full evolution of the gas—as evinced by the strong odor from the gas jets before applying a light. It is as well never to put one's face very near the acetylene lamp when lighting it.

Explosion in Carbureter—This annoying defect is known as popping of the carbureter. It is probably due (1) to one of the inlet valves being badly seated so that a minute flame can jet out sufficiently to ignite the mixture in the ignition-pipe. (2) Alternatively (as the inlet stroke comes immediately after the exhaust stroke), if the inlet valve is forced open too early by its cam at a time when some residue of exhaust gas is present in the cylinder (at or near a red heat), the opening of the inlet valve allows this heat to reach the new charge of mixture. This charge is thereupon fired on its way into the cylinder in the inlet-pipe as far back as the carbureter. Under these circumstances the carbureter appears to be the chief source of sound.

With the second class of popping the same loss of power is experienced as if there were a misfire. It is to be noted that the higher the speed of the engine and the greater the back pressure due to the muffler, the greater is the chance of the unexhausted residue being hot enough to fire the new charge. Some cars suffer from popping in the carbureter whenever the mixture is made too weak. This is due to the slow burning character of a weak mixture conducing to cause the second condition named above.

Explosion in Muffler—This is caused by a charge of gas, which has failed to explode in the cylinder, being ejected into the muffler and there becoming ignited by the next ejection of burnt gases. See Repairs and Adjustments.

This occurrence is somewhat startling the first time it is

observed by a beginner. It is quite harmless, though sometimes the muffler itself may be damaged or split.

To safeguard the muffler some makers fit a relief, that is, a plate which is held on to the body of the muffler by springs only. On an explosion occurring the pressure raises the plate and the gases pass away harmlessly.

The causes of these noises are manifold. Broadly, they will arise from any combination of circumstances which provides an explosive mixture in the exhaust-box and a hot flame to ignite it. For example, misfires, too rich a mixture, bad timing of the valves, valve sticking up, or lifted up to relieve compression, etc.

1. Misfires always result in an unexploded charge of gas being poured into the muffler. It is just a chance whether this charge will have been sufficiently diluted with the carbonic oxide and other waste gases already in the muffler to avoid being ignited by the heat of the exhaust on some succeeding stroke of the engine.

2. The use of too rich a mixture. This leaves unburnt gasolene in the exhaust gas, and if it should happen that air was already in the muffler, or is afterwards let in, the resultant mixture may fire. Cutting off the spark to stop the engine for the sake of a restive horse will sometimes result in the necessary air being imported, and a loud report results, to the great indignation of the horse driver, who thinks it was done on purpose.

3. Bad timing, that is, too late closing of the exhaust valve, may allow an appreciable aspiration of air into the muffler when running down hill with the throttle nearly closed. On reopening the throttle one of these explosions will result.

4. A very weak spark or poor ignition of the charge encourages these explosions.

5. Retarding the spark to an excessive extent makes the exhaust more noisy, though this only approximates to the regular muffler explosion in violence.

6. The existence of a particle of incandescent carbon or metal in the muffler may cause an explosion to occur some 30

or 40 seconds after the engine has been stopped, the delay being due to the slow convection of the gases to the incandescent part.

See Popping in the Muffler, under Driving; also Back Fire.

Explosion Motor—See Explosion Engine.

Explosions, Missing—See Missing Explosions.

Explosive Mixture—The combustible gas formed by a mixture of hydro-carbon and air, and used to produce power by explosion or expansion in the cylinder of an internal combustion engine. See Carbureter.

Exponent—The number or letter which, placed above a quantity at the right hand, denotes how often that quantity is repeated as a factor to produce the power. Thus, A^2 denotes the second power of A; A^4 denotes the fourth power and so on.

The exponent of a ratio is the quotient arising when the antecedent is divided by the consequent; thus, 6 is the exponent of the ratio of 30 to 5.

Exposed Chains—See Care of Naked Chains under Chains.

Express—The American system of despatching or conveying freight at a speed much superior to that of ordinary freight movement, under special safeguards and guarantees, at special fixed rates.

Extemporizing Repairs—See Makeshifts, Driving, Repairs, etc.

Extemporizing a Valve Spring—See under Driving.

External Brakes—See under Brakes.

Extinguishing Burning Gasolene—Sand or soil is generally advocated as being of more use than water for this purpose. Anybody who has tried to extinguish flames on a blazing engine with sand realizes the difficulty of doing so at all effectively. A better extinguisher would be a hand grenade, and a stock of these, at suitable distances apart, should be fixed on the walls of each public garage, and even in private car-houses. It would also be worth while to carry one on every high-priced car. They cost but little, and may be the saving

of many hundreds of dollars, as they do their work well, and are very easily used.

Extra Gasolene Tanks—See under Gasolene.

Eye—A loop or ring for fastening rigging, etc.; an eyebolt; an opening intended to receive a handle, pin, shaft, etc., as in an ax, wheel, crank or anchor.

Eyebar—A bar of steel or iron with an eye at one end or both.

Eyebolt—A bar or bolt of iron with an eye at one end.

Eyelet—A metal ring used to protect an eye or hole in canvas, leather, etc., by being pressed around its edge.

F

F.—In electricity, the abbrevation of Farad.

Fabric—The structure of anything; the production of weaving or the allied arts, as canvas, cloth, etc. The woven material used in the manufacture of pneumatic tires.

Face—In a general sense, the surface of a thing, or the side which presents itself to the observer; the visage. In geometry, a plane surface of a solid or one of the sides bounding a solid. In mechanics, that part of the cog of a geared wheel which extends beyond the working diameter; also the edge of a cutting tool, etc.

Face-hammer—A hammer with a flat face or striking plane.

Face-mask—In automobiling, a protection for the face.

Face-plate—A plate which shields an object from shock and wear; a disk attached to the revolving spindle of a lathe, to the face of which the piece to be turned is often clamped.

Fagoting—In metallurgy, the act of cutting bars of metal into short pieces which are made up into bundles or fagots, reheated, welded together and rolled or drawn out into bars —sometimes done to secure uniformity of texture and greater strength.

Failure—A deficiency or cessation of supply; omission or non-performance; as, the failure of an electric current.

Failure of Coil—See Coil Troubles, under Involuntary Stops; also Ignition.

Failure of Gasolene—See under Involuntary Stops, Gasolene, etc.

Failure of Ignition—See Ignition Troubles, under Involuntary Stops; also under Ignition.

Failure of Magneto—See Magneto Management, under Magneto.

Failure of Pump—See Overheating, under Engines.

Failure to Start—See Difficulty in Starting.

Fall—The act of dropping or descending from a higher to a lower place by gravity; extent of descent. That part of a hoisting rope, etc., to which the power is applied.

False Frame—See under Frame.

Fan—In the most common system of water cooling the water is pumped through a radiator placed in front of the car. In order to further assist in the cooling, a fan is often arranged behind the radiator to help in drawing the air through, and thus more rapidly radiating the heat away from the water. This fan is of the rotary type, having three or more blades, which are made of some light material, such as aluminum. The fan is mounted on a ball or other bearing to reduce friction, and is generally driven by a flat belt from the end of the engine crankshaft. Sometimes V pulleys are used, and a twisted rawhide or sound catgut band is adopted instead of the flat belt. In most cases some means are provided for altering the distance of the fan spindle from the engine shaft so as to allow of the tension of the belt or band being adjusted.

In another system, which has been largely used by French makers, the engine flywheel arms are cast in such a shape as to form a fan. In such cases, of course, the whole of the engine and all parts between the flywheel and the radiator must be closed in by sheet metal, so that the fan can only draw air in through the radiator.

In yet another form, vanes, helically placed, are attached to the periphery of the flywheel serving the same purpose. The advantage of the latter position lies in the speed at which the periphery of the wheel travels as compared with the center and arms.

In some cars the fitting of a fan behind the radiator so increases its heat radiating properties as to render the pump unnecessary. In such cases the water is circulated solely by thermo-syphonic action. See Circulation.

A warning must be given to those not greatly used to ex-

amining an engine that the fan revolves so fast that its blades are practically invisible, and a careless person may receive a painful blow on the hand in attending to or lubricating some part in the front of the engine.

An easy and rapid means of taking up the stretch of the belt is essential. Do not tighten the belt while the engine is running.

Fan-belts—See under Engines.

Fan-belt, Steel Spring—See under Circulation.

Fan Hitting—See under Pounding and Knocking.

Fan Not Working—See under Overheating.

Fang Bolt—See Bolts and Nuts.

Farad—In electricity, the standard unit of electromagnetic capacity; the standard possessed by a conductor which is capable of holding one coulomb of electricity at one volt potential. Named from the great electrician, Michael Faraday.

Fast—Firmly fixed, as a fast pulley.

Fast Pulley—A pulley firmly attached to the shaft from which it receives or to which it communicates motion.

Fastener—A clip for fastening together the ends of belts, such as are used for operating fans or transmitting the power from the engine to the road wheels of bicycles.

Fastening Screw—See Bolts and Nuts.

Fat Spark—A phrase which has arisen in connection with the coil and battery type of ignition to describe an electric spark short in length but great in width, in contradistinction to the thin or attenuated spark. The fatness or thickness depends, as a rule, on the strength or intensity of the current, hence the desirability of this robustness.

If the points of a sparking plug are placed about one millimeter (or 1-25th of an inch) apart, and there is a good voltage from the battery on making contact, so as to set up an induced current, a "fat" spark usually results. It has the appearance of a halo or zone of radiance bushing out on each side of a line drawn between the points of the sparking plug.

Now, separate the platinum points another millimeter, and the spark will be seen to be a thin, thready one, and without any of the surrounding iridescence.

A thin spark may also be caused by want of power in the induced current of the secondary coil. The causes of this may be faulty design of the coil, imperfect regulation of the trembler contacts, or the contact maker, or insufficient current from the battery. It should be understood that unless the source of the current, namely, the battery, is in a condition to give a good current, the spark will be thin, so that it is essential before trying to improve it by testing the coil, or reducing the distance between the points, to make sure that the battery gives its full voltage when a current is being taken from it, and to make sure that there is nothing in the primary circuit to reduce the current by causing a resistance to it. See Repairs and Adjustments.

It should always be borne in mind that the spark is larger under ordinary atmospheric pressure than it is in the cylinder at the compression stroke. The increased pressure and temperature affect its intensity, and allowance must be made for this.

Fathom—A measure of length containing six feet—the space to which a man may extend his arms, which was the original signification of the Anglo-Saxon word. Used chiefly for measuring cables, cordage and the depth of the sea in sounding by a line and lead.

Fatigue—Motoring is sometimes attacked as being the cause of nervous fatigue. When an occupation is interesting and involves no muscular effort, it need never be fatiguing; on the contrary, the fact that it stimulates interest makes it a distraction and therefore a rest by compelling the attention to abandon mental worries which otherwise disturb the physical system and prevent sleep. It has been well said that those who suffer from nervous strain in automobile driving are chiefly those who have been subjected to some of the following adverse conditions:

1. Hard road conditions, including sandy or rough road surfaces and difficult and dangerous grades and turns.

2. The attainment of high speeds, which call for an unusual degree of alertness from an unaccustomed driver or passenger.

3. A steering gear imperfectly irreversible or with much backlash.

4. Timid horses, dogs, etc., to be encountered on the road.

5. Unreliable car.

6. Car which requires the utmost skill to make it travel successfully.

7. Night driving, especially with bad lamps.

None of these are essential attributes of automobiling, and may, with a little forethought, be avoided for the most part.

Faucet—See Spigot.

Fault—A deviation from duty. In electricity, a defect in the efficient operation of a circuit, caused by ground and cross contacts or disconnections.

Fault Finding—In the finding of faults in a motor, or the diagnosis of trouble, the observance of the maxim "Festina lente" and a modicum of patience will stand the motorist in good stead.

If the machine fails to go, suspect the electric ignition, and read the article under Ignition Troubles, turning also to the descriptions given under Ignition of the particular form which is in use in the car in question. You will then see that all electric ignition systems have at least a low tension circuit; see if that is complete and working by causing the trembler blade to vibrate. This must be done by hand in the case of systems employing no trembler on the coil. See if there is a spark at their platinum points, and try this for all the coils (if more than one), noting whether none, one, some or all the trembler blades work or give a spark when vibrated. Then,

1. If no trembler works—

Examine the low pressure wires and the switch.

Test the cells.

2. If only one or other trembler works—

Observe which trembler does not work. Vibrate this one, adjust screw. Turn the engine and see whether the trembler now works.

If this is the case, clean the platinum of trembler.

If this is not the case, clean the rubbing contact pieces and replace.

3. If all tremblers work—

Observe whether (a) a high-pressure wire is broken or loose, or leaking; (b) a sparking plug is at fault; (c) all sparking plugs are at fault through water in cylinder or too much oil; (d) the secondary winding of the coil is faulty.

If lamp ignition: One burner has gone out, or one ignition tube has become leaky.

If the trouble is not in ignition, see Misfires, under Repairs and Adjustments.

If the trouble is merely loss of power, see Compression and Loss of Power.

If after recently taking engine apart, see if exhaust-valve timing is correct, or if engine is getting hot owing to faulty circulation of water.

See also that clutch is not slipping; if so, try to dry it with fuller's earth. I this fails, tighten the clutch spring, or substitute spare spring.

If all has been properly attended to without complete success the ignition must be examined.

Notice whether there is sparking at the spring contact when the circuit is made and the contact vibrated.

Cause of Breakdown.

If there is sparking—

1. Damp on the high tension wire or porcelain.
2. Defective or dirty sparking plug.
3. Dirty platinum on spring or screw.
4. Wrongly-set contact screw.

Cause of breakdown if sparking now appears at plug:

1. Leaky inlet or exhaust valve.

2. Piston rings not free.
3. Defective packing.

Cause of breakdown if there is still no high-tension spark at plug:

1. Defective induction coil.
2. Short circuit inside crack in porcelain.
3. Leaky high-tension wire.
4. Gap of intensifier too great.

If there is no sparking—

1. Broken wire or loose connection.
2. Dirty switch contact.
3. Run-down battery.
4. Lead lug of battery broken.
5. Defective induction coil or magneto demagnetized.

Other more serious causes are—

1. "Seized" piston or bearing.
2. Broken exhaust-valve stem.
3. Worn exhaust-valve stem, causing late opening of valve.
4. Wrong placing of gear wheel for half-speed shaft.

See also Misfires, under Repairs and Adjustments, and Missing Explosions.

Faulty Brakes—See under Driving.

Feather—A piece of metal of rectangular section which is half embedded in a slot cut in a shaft. It is usually kept in position by screws, though this is not absolutely necessary. In some cases the feather is solid with the shaft.

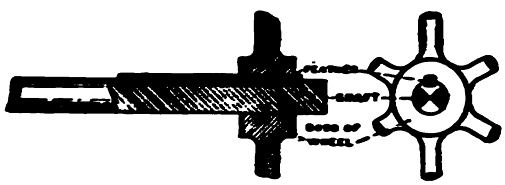
A gear wheel, pulley wheel, or any such part, having a slot corresponding to the feather cut in its boss is mounted upon the shaft, on which it is free to slide lengthways. It is prevented from turning thereon by the feather. It thus has the same circular motion as the shaft, but can be moved laterally along it. In many cases there is more than one feather, the number usually depending on the diameter of the shaft and the power to be transmitted.

An example of the feather is to be seen in several types

of speed changing gears where the wheels are required to be moved along a shaft.

The term "Sliding Feather" is used to describe the projectcin or feather fixed on or forming part of a wheel, and which slides into the slot in the shaft.

"Feather" must not be confounded with "Key." The latter is fitted much in the same way as the feather, and is the same shape, except that it has one face at a very slight angle to the other and acts as a wedge, holding the wheel on the shaft



FEATHER.

so that it can neither turn around it nor slide along it. It is either driven in from the end when the shaft and wheel are in position, or it is placed in a recess in the shaft and the wheel driven along the shaft on to it. The latter is the most general method adopted in good engineering practice. See Key.

Feather-headed Bolt—See Snug Bolt, under Bolts and Nuts.

Feather, Sliding—See Feather above.

Feed—To supply or furnish with anything of which there is constant consumption, as of fuel in a gasolene motor. The noun is used to designate any contrivance for giving to a machine a regular and uniform supply of the material to be operated upon, or the substance to be consumed. In the mechanical sense, feed is used in many compounds of self-evident meaning, describing the use to which various parts are put.

Feed, Differential—A device by which a tool, as a lathe, is made to operate with an even progressive movement.

Feed, Float—See Float Feed.

Feed Heater—Same as Feed-Water Heater.

Feed Pipe—The pipe carrying the liquid from which the power of the engine is generated.

Feed Pressure—A term which denotes that liquid, etc., is forced to its destination by air or steam pressure, instead of by a pump or by gravity.

Feed Pump—Sometimes called a force or plunger pump. See Pumps.

Feed, Sight—A visible drip system of lubrication for motor cars. See Lubricators.

Feed Tank—See under Tanks.

Feed Valve—See under Valves.

Feed-water—The water fed into a steam-boiler.

Feed-water Heater—See Steam Car, under Motor Cars.

Feed-water Regulator—See Steam Car.

Felloe—One of the curved pieces of wood, etc., which joined together by dowel pins or otherwise, form the circumference or circular rim of a wheel, into which the spokes are fitted. Also called Felly.

Felly—Same as Felloe.

Felt—A cloth or fabric made of wool, or wool and fur or hair, the fibers of which are not woven together, but matted or wrought into a compact substance by rolling and pressure, usually with the aid of sizing, heat and moisture. Also applied to a woven or felted material made of asbestos fibers, or any woven fabric that is partially felted.

Female Nut, Screw, etc.—The term used to designate a nut, screw, joint, etc., standing in a correlative or contrasting relation to another part of corresponding function. Thus, a female screw is a concave or internal screw into which a convex, external or male screw works.

Fend—To keep or ward off.

Fender—A mechanical device of a protective kind, as a rub-iron for the fore-wheels of a vehicle, a shield or mudguard over the wheels of a motor car, etc.; also the frame suspended in

front of a street-car to keep a person struck from being carried under the wheels.

Fenders Loose or Broken—See Miscellaneous Roadside Repairs.

Ferric—Pertaining to or extracted from iron, as ferric acid, acid of iron, and ferric oxid.

Ferro—A combining form used in compound words to signify iron.

Ferro-magnetic—Having the effect of iron in a magnetic field; the opposite of diamagnetic.

Ferro-manganese—A compound of iron and manganese employed in the manufacture of Bessemer steel.

Ferrous—Relating to or derived from iron; particularly having reference to iron combined in its lower valence, as "ferric" designates compounds into which iron enters in its higher valence.

Fetch—To go and bring; to draw into a certain place or relation.

Fiber—A filamentous substance; any substance which may be broken up into parts fit to form threads to be woven or spun. Particularly applied to coir, or the fiber of the cocoanut, used for cordage, matting, packing, etc., also to hemp, asbestos, etc. See Vulcanized Fiber and Ebonite.

Fiber Packing—See under Packing.

Fiber, Vulcanized—See under Vulcanized.

Field—In physics, a space subject to the action of some force exerted so as to act upon every point in that space.

Field of Force—The term applied to the space in which the magnetic action caused by a magnet is potent, usually referred to as the field of the magnet. See Coil; Ignition; Magnetic Field.

Field Magnets—See Principle of the Motor, under Electric Motor.

Fierce Clutches—See Attention to Fierce Clutches, under Clutch.

Fifth Wheel—In horse-driven vehicles a horizontal iron plate, in shape either a circle or a segment of a circle, placed on the forward axle, so that the fore part of the body may turn upon it freely without tilting.

File—A steel instrument used in cutting, polishing or abrading surfaces or edges of metal, etc. See Tools.

The cutting surface of a file is made in the steel while soft by a chisel which cuts grooves, leaving an evenly ridged surface. Files are named either from the nature or the number of the cutting faces, the shape of the tool, or the use to which they are put.

File-card—A device for cleansing files from metallic dust.

Fillet—In technology, a term having many applications, as the thread of a screw, a band or collar on a shaft, etc.

Filter—A device generally consisting in motor cars of fine wire gauze, placed in different parts of the system, to prevent dirt or foreign bodies entering and being carried with the fuel or water into the working parts.

In the water circulating system a funnel provided with a fine filter should be used when filling up with water. Water gauges, too, are sometimes fitted with a filter, though in this case it is not much use, as any deposit on the glass is caused by too fine a matter to be checked by the filter.

In the fuel system it is still more important to have filters fitted, as the pipes are always smaller than the water pipes, and consequently more easily choked. In practically all types of spray carbureters, the orifices of the spraying nipples are so fine that it takes very little to stop them. Even after the fuel has passed through two or three sheets of gauze, sufficient matter is sometimes carried with it to cause a blockage.

When filling up with gasolene, the funnel should have a piece of fine muslin placed so that the spirit must pass through it. This has the two-fold advantage of acting as a filter, and also preventing any water in the gasolene from passing through, the latter being held on the outside surface of the muslin, where it can be easily seen in the form of globules,

and should be immediately shaken off, as if left too long it will soak through.

Filters (which should be periodically examined and cleaned) are usually placed where the gasolene leaves the tank, at a point just before it enters the carbureter, and in pressure-fed motors at the pressure valves connected with the exhaust.

Filter, An Improved Gasolene—See under Gasolene.

Filtering—The operation of purifying water or other liquid by passing it through a porous substance that retains matter held in suspension in the liquid.

Filtering Carbureter—A carbureter equipped with a filter. See Filter above.

Fin—Anything resembling a fish's fin, as, in molding, a thin excrescence on the surface of a casting; any fin-like part or attachment.

Finger—Any device or part shaped like or performing the function of a human finger.

Finger Nut—A wing nut. See Bolts and Nuts.

Finger Screw—See Screws.

Finish—The last touch put on any work; polish; the decorative work or finishing touches put on a machine, a motor car body, etc.

Fire—See under Useful Information.

Fire-box—See Steam Car, under Motor Car.

Fire Extinguisher—A portable device or apparatus for putting out small or incipient fires. Some effective extinguishers throw a stream of water and carbonic dioxid; others are in the form of hand grenades containing a similar solution.

Fireproof—Constructed of incombustible materials or rendered incombustible by a special coating or covering.

Fire-tube Boiler—See Steam Car, under Motor Car

Firing—The act or operation of applying fire as by an electric spark to the combustible fuel or "explosive" mixture in an

internal combustion engine. The act of supplying fuel to a steam boiler.

Firing, Irregular, A cause of—See under Ignition.

First Speed—See Change Speed Gear.

First Trip, The—See Initial Trip, under Driving.

Fish-joint—A splice consisting of one or more oblong plates, pieces of iron or wood, bolted to one or both sides of two iron or wooden parts meeting end to end.

Fish-plate—One of the plates used in the construction of a fish-joint.

Fissure—A cleft or longitudinal opening; a narrow chasm made by the parting of any substance.

Fitting Accessories to a Car—See under Driving.

Fitting New Batteries—See under Battery.

Fixed Axle—See under Axle.

Fixing Screw—See Bolts and Nuts.

Flame—A stream of vapor or gas undergoing combustion and giving forth light. The non-luminous tip of the flame issuing from a blow-pipe is called the oxidizing flame and contains an excess of oxygen at a very high temperature. The inner luminous portion of the flame of a metal-reducing blow-pipe is called the reducing flame.

Flame Ignition—See under Ignition.

Flange—A suitably-shaped plate, either brazed, cast or otherwise attached to the extreme end of a pipe, by means of which two pipes are fastened to each other or to a member.

The ends of the water pipes on a motor are always provided with flanges, and are held to the cylinder by two or more studs and nuts. For steam and hot water, asbestos is sometimes used to make a tight joint, but a mixture of red lead, white lead, and boiled oil mixed to the consistency of thick dough spread over the faces makes an excellent job. This class of joint, however, has the disadvantage that it has to be re-made every time it is "broken." See Joints.

A blank or blind flange is a plate used to close an opening, as a cylinder-head or the end of a pipe.

Flange Coupling—A coupling of two parts by means of flanges bolted or otherwise fastened together.

Flange-joint—A joint formed by the union of two flanges, as when the ends of two flange-pipes are bolted together.

Flange-pipe—A pipe having a flange at each end to form connections, or piping of which each length has such flanges.

Flange-wheel—Any wheel flanged on one or both edges of the tread to prevent its slipping from the rail.

Flank—The straight part of the tooth of a gear-wheel, which receives the impulse in transmitting power.

Flap Valve—A hinge valve. See under Valves.

Flare Patches—See under Tires and Wheels.

Flare-up—A term used to describe the conflagration which occurs when gasolene which has leaked comes in contact with a light.

It is generally due to the carbureter flooding, or to a leaky connection, or to an oversight in fixing a connection, such as that between the supply pipe and the carbureter. A blow back of the ignited gas through the inlet valve is also very likely to cause a flare-up if the carbureter has been overflooded at starting.

In the case of a bad leak, where the gasolene streams about the footboard, it may become ignited from the lamps, or even from the exhaust pipe, should the latter happen to be exceedingly hot.

The first thing to do in the case of pressure feed is to turn off the pressure by opening the air tap, and in the case of gravity feed, to close the gasolene tap. The flames will then, as a rule, die down very quickly. There is no use trying to quench them with water. Sand is the most effectual means, but is, of course, seldom obtainable. Failing sand, a flare-up can be generally smothered and so put out by means of a heavy rug, sack, or the like, preferably soaked in water. Chem-

ical extinguishers are very successful, and there are good ones on the market. A syphon of seltzer water will often prove effective.

Flash—A sudden burst of light, flame, etc.

Flash-board—A board used to raise the height of water behind a dam, etc.

Flash Boiler—See Steam Car, under Motor Car.

Flash Generators, Steam Car—See under Steam Cars.

Flashing—In making electric lamps, a process of treatment in which the incandescent filament is subjected to a bath of carbon vapor to give it firmness and uniformity of resistance.

Flash-light—A light which is hidden and recurrent at short intervals.

Flash-point—The temperature at which a volatile oil gives off vapor that will ignite with a flash when it comes into contact with a flame. The flash-point or flashing-point of illuminating oils, etc., is fixed by law in most of the states and foreign countries, and must be considerably below the temperature at which the illuminant burns with a steady flame.

Flask—In foundry work, a frame or box with compartments for holding the sand in which a mold is made. If the mold is in two pieces these form a two-part flask, the upper part holding the case or cope and the lower part the drag.

Flaw—The presence of any foreign matter in metal causing a defect. A dissolution of the metallic particles in the process of manufacture. In cast iron a flaw is often caused by bubbles of air in the molten metal while being cast in the molds. Such flaws often make their presence known only after the metal has been machined.

Flexibility—The quality of being flexible. See Engine Flexibility.

Flexible—Capable of being adapted or accommodated to varying circumstances; not rigid.

Flexible Conductors—See Electric Conductors.

Flexible Coupling—A universal joint.

Flexible Engine—See under Carbureter.

Flexible Joint—A form of universal joint permitting of the bending or other free movement of a shaft.

Flexible Shaft—As the road wheels of an automobile are liable to rise and fall with uneven roads more than the springs allow the body and gear to do, the power must be transmitted through a flexible body, as a chain or shafting, with flexible or universal joints.

An elementary form of flexible shaft consists of a spiral spring. This method has been used to drive the circulating pump in some small cars. Like all spring devices, it is liable to suddenly betray the confidence reposed in it.

See under Shafts.

Flexure—The act or form of bending. In mechanics, a strain under which certain plane surfaces are bent or deformed.

Flitch—One of several planks, timbers or iron plates fastened together side by side to make a large girder or compound beam.

Flitch-plate—An iron plate fastened side by side with others to secure more solid and rigid construction.

Float—The part which floats in the float-chamber of a float-feed carbureter to regulate the supply of gasolene, etc., from the tank. Usually an air-tight hollow metal device. See Carbureter.

To find the leak in a float that sinks, immerse it in boiling water and watch for bubbles. Warming the float with a match after taking it away from the car will also help to disclose the puncture.

Float Chamber—The part of a carbureter in which the float operates. See Carbureter.

Float Feed—This is the term usually applied to that type of carbureter in which the level of the gasolene is maintained by means of a float. See Carbureter.

Also see Float and Needle Defects under Involuntary Stops.

Float, Fitting to Gasolene Tank—See under Gasolene.

Float Level Too High—See under Loss of Power.

Float Spindle—A spindle which is attached to the float in a carbureter. Sometimes it is attached directly, and sometimes it slides through the center of the float, and is operated by levers with which the float comes into contact. At one end it is ground to a taper point, which acts as a valve to stop the flow of gasolene when the float has risen to the correct height. It is usually called the needle valve. See Carbureter.

Floating Axle—A live axle containing a universal joint, etc. See under Axle.

Floating Axle Broken or Bent—See Miscellaneous Roadside Repairs.

Flood—A great quantity or superabundance, as of gasolene in a carbureter.

Flooding—The inflow or admission of an excessive supply of gasolene to a carbureter. See under Carbureter.

Floor, Drainholes in Tonneau—See under Carriage Work.

Flue—Any tube-like device for the passage of gas, flame or hot air, as the flues of a steam-boiler.

Falling off of the steam pressure in a steam car is sometimes due to the wind blowing down the flue and keeping the heat away from the boiler tubes. Temporary shelter given to the flue ends will get over the difficulty, which is more commonly met with in hill climbing than elsewhere owing to the decreased speed of the car allowing the wind to overtake it, while at the same time the demand for steam is largely increased by the "effort" of the climb.

Fluid—A body whose particles move easily among themselves and yield to the least force impressed, and which, when that force is removed, recovers its previous state. Fluids may exist in two forms, liquid and gaseous. In the former the molecules are more or less coherent, while in the latter they tend to separate indefinitely.

Fluke—The part of an anchor which fastens in the ground; a barb on a harpoon; also an accidental count or score.

Flush—To cleanse by forcing water or other liquid through. In mechanics, etc., the adjective flush signifies even or level in respect to surface.

Flush-bolt—Any bolt the face of whose head is even with the surface of the material in which it rests.

Flushing—The act of cleansing by a sudden flow of liquid.

Flux—In metallurgy, any substance or mixture used to promote the fusion of metals or minerals, as alkalies, borax, tartar, and other saline matter; or, in large operations, limestone or fluor-spar.

Flying Machine—An apparatus or device for navigating the air or flying through space, as an aeroplane or dirigible balloon. Aeroplane is the term usually applied to the heavier-than-air type of flying machine, such as that developed with remarkable success by the Wright brothers of Dayton, Ohio. Such devices as that of Count Zeppelin of Germany, which consists of a huge cigar-shaped sectional balloon, beneath which is suspended a framework with operating cars, etc., are often called dirigibles.

Great progress was made during the year 1908 in the results obtained and records made by aviators. Count Zeppelin and others made many notable flights in dirigible machines, with and against the wind, carrying passengers in large numbers, and demonstrating the practicability of aerial navigation with that class of machine within certain weather limits. Mr. Orville Wright, in the neighborhood of Washington, D. C., and Mr. Wilbur Wright, in France, made many remarkable flights in their aeroplanes, though the long continued success of the former was finally marred by an accident in the autumn, which resulted fatally to the United States officer accompanying him.

The progress of the year in aeroplane management is exemplified by the following facts: On January 13, 1908, M. Farman secured the aeroplane record of France with a flight of 1,000 yards. On December 18, 1908, Mr. Wilbur Wright flew 95 miles in his aeroplane after many other prolonged flights, at Le Mans, France. He attained a height of 350 feet

on this occasion, and remained in the air for one hour and fifty-three minutes, descending only on account of physical fatigue.

Flying machines of both the Zeppelin and the Wright types are usually equipped with gasolene motors, which operate propellers of canvas, aluminum or some other light material.

Fly Nut—A nut with flattened wings, to be turned by the thumb and finger. See Bolts and Nuts.

Flywheel—The heavy wheel attached to a gasolene motor or other engine to render its movements uniform, its inertia tending to resist either sudden acceleration or sudden retardation of movement. See Wheels.

The object of the flywheel is to equalize the rotation of the crankshaft by storing up the force of the impulses and giving it out again during the exhaust, induction, and compression strokes. In motors having more than one cylinder the flywheel effect is less necessary in rough proportion to the number of cylinders, as the impulses are more frequent, and some, if not all, of the idle strokes are balanced more or less by impulses. Or, to put it more directly, the single-cylinder engine stands most in need of a powerful flywheel.

A large diameter flywheel is of more effect than a smaller one of the same weight and proportions, as in the former the weight acts at a greater leverage. For this reason it is desirable to make the rim the heaviest part of the wheel. The momentum of the mass of metal resists changes of speed, whether they tend toward increase or toward decrease, and to this is due the equalizing effect of the flywheel. Were it not for the flywheel or some equivalent device, the motor and the car would be forever nagging at one another, the motor driving the car on each impulse stroke, and the car driving the motor at other times. As in other nagging, there would be a violent interchange of "torque."

Though the flywheel seems to be one of the simplest things on the car, it is associated with one of the most interesting scientific phenomena, namely, gyroscopic action. We are all

familiar with those willful tops which appear to exhibit a total disregard for the laws of gravity by spinning on a one-sided, instead of on a vertical, support. The crankshaft and flywheel of a motor have it in them to play similar pranks if given the chance. So long as the car carries the crankshaft either straightforward in the direction of its length or broadside on, the flywheel is docile enough; but every time one turns a corner, the flywheel tries to turn the motor up on one end or the other, according to the respective directions in which the car and the flywheel are being turned. Generally the motor tends to tip up on its front end when the car is being steered to the left and on its rear end when it is being steered to the right, the rule being: When a flywheel, rotating about its axis, is moved about another axis, the flywheel axis tends to set itself parallel to such other axis, with the flywheel rotating in the same sense or direction as the movement about the said other axis. From which it may be safely concluded that the motor should be very securely fixed to the frame of the car.

Foam-cock—In steam boilers, a cock at the water level by which scum is drawn off.

Foaming—The condition of the water in a steam boiler when it is frothy from dirt, etc.

Follow-board—In founding, a smooth board with a plane surface for holding the pattern and the flask while the sand is being packed in; a molding-board.

Follower—In mechanics, the part of a machine that receives motion from another part. In a steam engine the cover of a piston or of a stuffing box.

Follower-plate—In machinery a plate serving as a follower, that is, moving in a limited range, as in guides, and following the motion of another part.

Foot—The lower part or base of anything.

A unit of length, originally the length of a man's foot. The United States foot of 12 inches is equal to 30.48 centimeters.

Foot Accelerator—A pedal close to the driver's foot, and

held up by a spring, for increasing the supply of gas to the engine.

Foot-brake—A brake applied by means of a pedal.

Foot-mats, Securing—On many cars the corrugated foot-mats used are secured to the floor or running boards, as the case may be, by the somewhat flimsy expedient of tacked-down strips of brass or aluminum at their edges, small escutcheon pins being used for the tacking. The objection to these is their tendency to loosen up and work out under prolonged vibration—a tendency almost sure to manifest itself in time, no matter how carefully the work has been done or how closely the tacks may be spaced. Because of these considerations, it is good advice to the motorist who is using a car that has foot-mats secured by tacked-on strips, to urge that the tacks be replaced by small round-headed brass screws. By substituting these at the earliest convenience, and at a cost which is trivial, in both labor and money, it can be depended upon that loosening of the strips, and thus of the mats, will not occur. Another fault that sometimes is to be found with the affixing of mats is the lack of anything but tacks to hold down the material in a corner, as where it comes from a floor onto a vertical surface. In such a place, a holding-down strip similar to the ordinary stair-rod is apt to be in every way an improvement over anything else.—Motor Age.

Footstep—In mechanics, the part or pillow upon which a vertical shaft rotates. A footstep bearing is the box or bearing on which an upright shaft revolves.

Foot-valve—A valve at the bottom of a cavity or cylinder opening upward; especially the valve in a steam engine opening between the condenser and the air-pump.

Foot-warmer—A device, often consisting of a flat metal box containing heated or burning fuel, as charcoal, etc., for keeping the feet warm while automobiling.

Force—In physics, that which is the source of all the active phenomena occurring in the material world, of which motion, gravitation, heat, light, electricity, magnetism, cohesion, chem-

cal affinity, etc., are believed to be exhibitions; that which produces or tends to produce change; energy.

Force, Centrifugal—The tendency of bodies to recede from the center as in the case of comets and meteors flying off from their parent bodies. Centrifugal machines, setting up a whirling motion, are used to drive moisture out of damp articles, separate fluids of different densities, raise water, etc.

Force, Centripetal—A force which draws a body towards a center.

Force, Electromotive—The cause of the establishment and maintenance of a difference of potential and therefore a flow of current between any two points. Commonly abbreviated as E. M. F.

Force Feed—See Pressure Feed.

Force-feed Lubricator—See Lubrication.

Force, Field of—See under Coil.

Force, Lines of—See under Coil.

Force, Live—The older writers described live force, or "vis viva," as the measure of the mass multiplied by the square of that of the velocity; but recent writers have used the phrase to signify one-half of that quantity.

Force, Magnetic—A force which tends to make a magnet assume a position in the direction along which the force acts; also applied to the forces of attraction and repulsion characteristic of a magnet.

Force, Moment of a—In physics, the moment is a unit of force producing or tending to produce rotary motion. The moment of a force is thus (a) with reference to a point, the product of the force into the distance of its point from its line of action; (b) with respect to a line, found by resolving the force into two components, one parallel and the other perpendicular to the line, and then taking the product of the latter component into its distance from the line; (c) with respect to a plane, the product of the force into the distance of its point of application from that plane.

Force-pump—A pump which delivers the water or other liquid under pressure, so as to eject it forcibly or to a height. See under Pumps.

Force, Unit of—The single force in terms of which the amount of any other force is ascertained, and which is generally some known weight, as a pound.

Forced Circulation—A system of water circulation under pressure; used for cooling purposes in gas engines, etc. See Circulation.

Forced Lubrication—A system of lubrication in which the oil or grease is forced into the parts to be lubricated under pressure. Distinguished from a drip system, etc. See Lubricators.

Forecar—A term sometimes applied to a passenger attachment fixed in front of motorcycles.

Fore Carriage—A term taken from horse-drawn vehicles, in which it consists of the lower carriage which turns on the upper or top carriage.

In a motor car, where the steering is totally different, the fore carriage comprises the two front springs and axle, together with the rods and stays connecting them to the frame and steering wheel.

Also applied to a passenger attachment fixed in front of motorcycles.

Forge—To mold or shape wrought iron or steel by heating and then manipulating by pressing, stamping between dies, working with hammer and swage, etc. Any ductile metal can be similarly worked. The hearth upon which the fire is made, or the building containing such hearths, is usually known as a forge.

Forging—A piece of forged work in metal; a general name for pieces of hammered iron or steel.

Forging, Drop—Metal forged by a drop-press or drop hammer. See under Drop.

Fork—A pronged device used for operating gears. It is

used to slide a gear wheel along a shaft, or to slide the collar which operates a clutch along its shaft. In each case the wheel or the collar has a groove turned in the periphery of its boss or hub with which the fork engages. When the fork is moved it carries the wheel or collar along with it, the latter meantime revolving with the shaft. See Change Speed Gear.

Formed—A term applied to a storage cell after the chemical changes requisite for its purposes have repeatedly taken place. See under Battery.

Formula—Any prescribed form or rule; a general expression for resolving mathematical problems; in chemistry, a term applied to the symbols representing the different substances.

Fouling Radiators—See under Circulation.

Founding—The art of casting or forming of melted metal any article, according to a given design or pattern.

Foundry—A building occupied, fitted and furnished for casting metals.

Foundry Iron—Iron containing the proper amount of carbon to render it fit for castings.

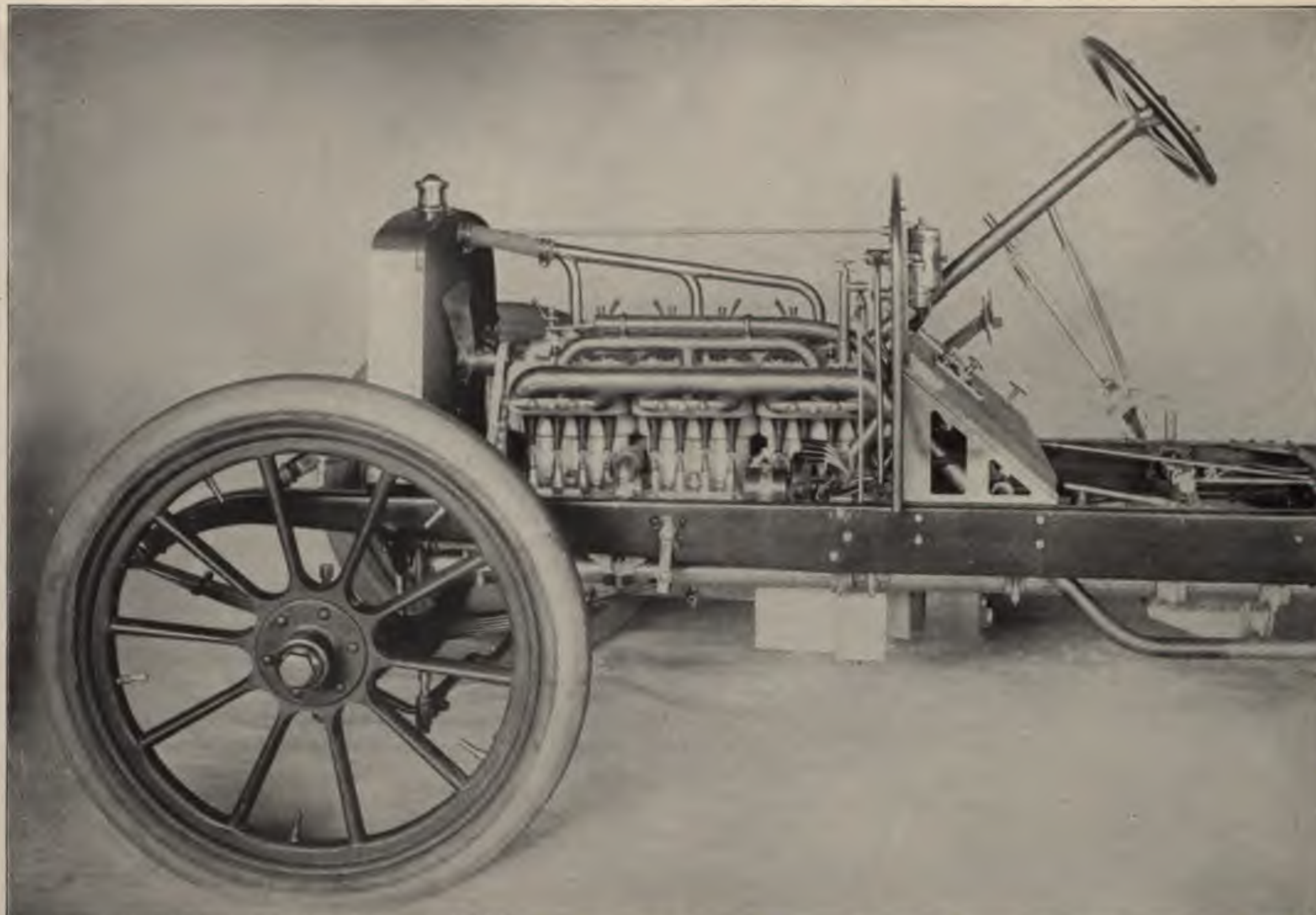
Foundry-work—Same as Founding; also applied to the castings made in a foundry.

Four-cycle Engine—See Internal Combustion Engine; also under Engines.

Four-cylinder Ignition Timing—See Multi-Cylinder Timing, under Ignition.

Four-way Cock—A kind of automatic valve used for passing steam alternately to the upper and lower ends of the cylinder and to the condenser, in a steam engine, and for other purposes. In the usual form, when the center is turned a quarter of a revolution the action is reversed.

Frame—The metal framework of a car. The French term "chassis" is now used to describe the frame with the engine and mechanism fixed or suspended thereon. See Chassis.



Lozier "Little 6" Chassis—View of Front End, Showing Tubular Sub-frame.

The motor and its appurtenances, the transmission gear, the springs with the axles and wheels, and the body, are all assembled upon the frame. The frame is generally rectangular in plan, but narrowed towards the front to allow of the steering wheels being deflected through a greater angle. In side elevation the main frame frequently departs from a single horizontal plane, the rear end being raised to give more play for the springs.

Varieties of Frame Construction.

The earliest frames were constructed very largely of wood, but now metal is the predominating material. When wood is employed, it is reinforced by metal flitch-plates. These should be deepest in the middle of the frame and tapered off toward the ends to prevent sagging. Frames built of weldless steel tubes were more common formerly than now, though still employed in some small cars and for racers. Car makers who have had cycle manufacturing experience are those who generally go in for tubular frames, as they are used to the class of work. A few firms use square-sectioned tubes plugged with wood; these make a very good frame. Channel section iron or steel was at one time very popular for frame construction, but this has now been very largely superseded by the pressed steel frame. In this last, sheet steel is pressed in powerful presses to a [section, the web being made deepest in the middle and shallower toward each end of the frame. The pressed steel frame has been very cleverly developed, and is in some cases made with an integral apron or shield to cover in the underside of the motor and gearing—to form a kind of engine room floor, in fact. These shields are a great protection to the mechanism and save a deal of cleaning and the loss of some small parts that would otherwise be dropped; but it is more convenient to have them in detachable sections than as a permanent fixture. When a car is not made with a shield in the first place, one should be fitted as soon as possible. It may be made of leather or prepared canvas, instead of metal, if preferred.

The Question of Rigidity.

The frame should be braced transversely by cross bars; and, unless naturally of girder formation, may be strengthened vertically by trussing with tension rods and king posts. It is almost hopeless, however, to attempt to build a really rigid frame of anything like reasonable weight. All four wheels have to find a footing on roads that are often uneven; and as the play of the springs is somewhat limited, one can only expect the frame to do a bit of compensating on its own account. This being so, it is important that the various elements, such as the motor, the change-speed-gear box, and the back axle, should be mounted and connected by means that will prevent any harm arising from moderate disalignments. The gear box often, and the motor occasionally, is supported on three or more points, to allow it to adapt itself to internal movements of the frame. On the other hand, the motor and gear are sometimes connected en bloc to prevent any disalignment. Apart from this consideration, the motor and gear box are often carried on a smaller frame—known as the inner frame, underframe, or sub-frame—mounted within the front portion of the main frame. Nowadays, however, it is more usual to mount these parts directly on the members of the main frame. Provided the inner frame is well constructed and attached—and it is very often wanting in the latter particular—there is not very much to choose between the two systems.

As cars have frequently to pass over very uneven surfaces, a good many frames have the front axle pivoted to the main frame on a fore and aft axis. This, of course, allows the two wheel axles to set themselves at quite alarming angles without straining the frame at all.

Frame Broken, Temporary Repair—See Miscellaneous Roadside Repairs.

Frame, Cambered—The frame of a motor car made narrower in front to permit of greater facility in turning.

Frame Cracked or Broken—See Miscellaneous Roadside Repairs.

Frame, Dropped—A frame that has a downward curvature.

Frame, False—A sub-frame, under frame, or cradle for the support of the power-plant, etc., of a motor car. See Frame.

Frame-hangers—The dumb-irons or spring-hangers at the extreme ends of a chassis.

Frame, Rigidity of—See under Frame above.

Free—Unconstrained; unrestrained; not chemically combined with any other body, as free carbonic acid gas; not attached or fixed.

Freeboard—The portion of the side of a ship or boat between the rail or gunwale and the water.

Free Wheel—A road wheel is said to be a "free wheel" when it is so mounted that it can freely overrun the mechanism which drives it.

A pawl and ratchet which is the simplest form of the device has the drawback of being noisy and of only acting in steps. This is overcome by providing, instead of the pawl, that a small steel ball shall run up an inclined plane and jam the driving and driven parts together. Occasionally, and particularly if fine dirt and dust gets into the mechanism, the balls fail to run forward into the wedge-shaped space where they are intended to be locked, and then the free wheel is said to slip —that is, to become free in both directions of rotation for a small movement. With motorcycles in which the engine is started or assisted up a hill by vigorous pedaling, this slip of the free wheel is a very dangerous thing to the internal economy of the rider, who is liable to make a violent effort and to find suddenly that all resistance has been removed. The way to be sure of avoiding this is to wash out the free wheel ball races after a ride through very wet mud, which, by the way, appears to be a worse enemy in this particular direction than fine-blown dust.

Lay the cycle on its side, inject kerosene through the oil hole and spin the wheel while flooding the hub. This process must be continued alternately with kerosene and gasolene for as much as twenty minutes till all the impalpable dirt is re-

moved from behind the pawls or the balls and from the little coiled springs which actuate them.

Freezing—The process or state of congelation due to low atmospheric temperature.

Freezing, Anti-Mixtures—See under Anti-freezing.

Freezing of Carbureters—See under Carbureter.

Freight—The cargo or any part of the cargo of a ship or railroad car; goods in transit; also, the charge made for transporting goods.

French Chalk—A fine, dry, white powder, classed among the dry lubricants, such as plumbago, etc. It is non-adhesive, and plentifully used will prevent cohesion between parts. Largely used in tire manipulation. After repairing a puncture by applying a patch to the inner tube, the chalk is well spread over the patch to prevent its sticking to the outer cover. In replacing a tire this chalk should be used plentifully, as it prevents, to a certain extent, the tube becoming overheated on long or fast runs.

French Horse Power—See under Horse Power.

French Measures—See Metric System.

Frequency—In physics, the number of occurrences in unit time, as the frequency of explosions in a gas engine in a minute.

Friction—The resistance offered to a moving piece of machinery by the surface on or in which it moves.

Every moving piece of a motor car which has its surface in contact with the surface of another part, whether this latter is moving or stationary, suffers from friction, all of which is loss of power. The only part in which a certain amount of loss through friction is utilized and necessary is in producing a flexible connection in some part of the transmission between the engine and the road wheels.

It is impossible to eliminate friction altogether, but as it is a dead loss of power, every endeavor should be made to keep it as low as possible. Good design helps to reduce those losses

which occur through defective proportions in engine and gearing, wasteful angles of application of power, and improper methods of transmission. Good workmanship means the highest finish, correct fit, and proper alignment of all parts. But both these are useless without good lubrication; in fact, the better the finish and workmanship the more necessary is proper lubrication. The object of lubrication is to produce a thin, slippery film of lubricant between the bearing surfaces, and so reduce the resistance they offer to motion. See Lubrication; Repairs and Adjustments.

For Dry Surfaces—Frictional resistance is (a) nearly proportional to the normal pressure between the surfaces.

(b) Nearly independent of speed for low pressures.

(c) Is not greatly dependent on temperature.

(d) Depends largely on the nature of the materials in contact.

(e) Friction of rest is slightly greater than that of motion.

(f) When pressure becomes excessive seizing occurs.

(g) The frictional resistance decreases with "wear."

For Lubricated Surfaces—Frictional resistance (a) with bath lubrication is almost independent of pressure, but approaches the behavior of dry surfaces as the lubrication becomes more meager.

(b) Varies directly as the speed for low pressures, but for high pressures is very great at low speeds; becomes a minimum at about 100 ft. per minute, and afterwards increases as the square root of the speed.

(c) Is extremely dependent on temperature. It is highly important to maintain a low temperature in bearings. With hot bearings a thick lubricant such as vaseline, may be temporarily employed with advantage.

(d) With flooded bearings is but slightly dependent on materials in contact, but approaches the laws of dry friction as the lubrication becomes more meager.

(e) Friction of rest is enormously greater than that of motion, especially with thick lubricants.

(f) The pressure of seizure depends on the viscosity of the lubricant.

(g) The frictional resistance increases with "wear."

Frictional resistance is always greater immediately after the reversal of direction of sliding.

Friction, Coefficient of—Frictional resistance is generally considered in the following way:

The load carried by the bearing, etc., is noted, and the force required to move the rubbing surfaces past one another under that load is noted. This force is then expressed as a fraction of that load—the fraction being called the coefficient of friction.

Turning for simplicity of illustration to ordinary sliding friction, if a load of 1 ton resting on a surface can be moved by a ¼-ton pull, the coefficient of friction of the two surfaces in contact is said to be one-quarter (or 0.25).

With plain bearings (made of bronze carrying a steel shaft), the coefficient is approximately..	0.04
With ball bearings the coefficient is about......	0.0065
With roller bearings the coefficient is about....	0.012
With plain bearings the coefficient at starting is about	0.05
With roller or ball bearings the coefficient is about	0.006
Between rubber and macadam road surface the coefficient is about	0.6
Between cast iron of flywheel and clutch leather, when all is dry, the coefficient is about.........	0.3
Between cast iron of flywheel and clutch leather when some oil has got out into the faces, it is about	0.2
Between unlubricated metal and metal the coefficient is about	0.2

It must be remembered, however, that these coefficients vary with the speed, the load, the temperature, and the lubricant.

Friction Brake—A brake operating by friction. See Brakes.

Friction Clutch—See under Clutch.

Friction Cones—A form of slip coupling consisting of two cones fitting each other accurately. The transmission of motion depends on the friction of the two conical surfaces. See Change Speed Gear; Clutch.

Friction Coupling—A coupling in which the connection is made by the friction of two surfaces.

Friction Drive—A system of driving road wheels in which the power is transmitted to the rear axle by the friction of two surfaces brought into contact for the purpose.

Friction Gear—See Gear and Gearing; Change Speed Gear.

Friction Loss—Taking the motor car as a whole the total friction loss is the difference between the power developed by the engine and that available at the road wheels. To this must be added the friction loss in the engine itself—that is, the difference between the theoretical power, after allowing for heat losses, and its actual power.

Friction loss is necessarily a high figure in motor cars where the several parts are confined to certain positions in a limited space, so that wasteful modes of transmission have to be employed. Moreover, the necessary reduction and variable speed gearing for a constant speed engine is a great source of loss.

Friction, Rolling—The resistance of uneven surfaces rolling on one another, like that of a wheel rolling on a road.

Friction, Sliding—The resistance to the relative sliding motion of surfaces of bodies in contact.

Friction Wheel—A form of slip coupling applied in cases where the variations of load are sudden and great.

Frictioned Duck—A term applied to a canvas fabric treated with rubber and used in the manufacture of tire casings.

Front Axle—See Axles.

Front Braking—Considerable discussion has arisen over the advisability or otherwise of applying brakes to the front wheels of vehicles so as to divide the strain and thus allow of the vehicle being pulled up in less length without any increase

of strain upon it. The idea has only as yet been applied experimentally. It is said to minimize the risk of side-slipping in greasy roads.

Front Driving—A method of arranging the transmission mechanism so that the front wheels are the drivers. It is not at all in common use, though it has some advantages, particularly in city traffic, as it allows of turning in a very narrow circle, and also isolates the carriage body part of the vehicle from engine and transmission vibration.

Front Tires, Wear on—See under Tires and Tire Repairs.

Front Wheel—See Wheels.

Front Wheel Smashed—See Miscellaneous Roadside Repairs.

Frost—That temperature of the air which occasions the freezing of water. See Radiators, Circulation, Driving, etc.

Frosty Weather—See Cold Weather.

Frozen Roads, To Avoid Sideslip on—See under Driving.

Frozen Water—In water, during the process of freezing, the upper layer is first cooled and becoming heavier than the main body of water falls to the bottom. This continues until 4 degrees Centigrade is reached; the water nearest the surface is then frozen and, expanding, becomes lighter than the rest. Ice is thus formed on the surface and thickens from below.

In a pipe the ice first forms round the circumference and thence inward. As water freezes it expands and causes a great pressure on the containing vessel, which if too weak to stand the pressure bursts.

Preventing—By adding chemicals to the water the freezing point is lowered, and if the water were always kept at a very low temperature the number of substances that could be added without injury to the pipes, etc., would be fairly large, but the number is limited by the fact that during the working of the engine the temperature is raised to nearly boiling point. This heat is quite sufficient to decompose many of the added substances, setting free agents which would at-

tack and eat away the metal of the pipes and tanks. A safe but expensive substance to add to the circulating water is glycerine, in the proportion of a 30 per cent. solution, which is quite sufficient to reduce the freezing point low enough to resist any ordinary frost; but it must be kept in mind that fresh glycerine must be occasionally added to make up for the losses which occur through the glycerine being carried off with the steam. Calcium chloride can also be used for the same purpose; it is cheap, easily obtainable, and it is stated by those who often use it to be innocuous. It is safest, however, to run the water out of the tank and circulating system every night during frost. In doing so all cocks in the system should be opened. In spite of this precaution water may possibly remain in the pump and get frozen. Any attempt to start without thawing it might prove disastrous. The best way to get rid of this ice is to put hot cloths round the pump. See Cold Weather.

Fuel—See Gasolene, Liquid Fuel, etc.

Fuel Consumption—The consideration of the amount of fuel which is consumed in a given time in generating a given power in an engine is of much importance to the motorist. In ordinary steam engines and locomotives, fuel consumption is calculated at so many pounds of coal per horse power per hour. In the same way the internal combustion engine's consumption is calculated at so much gasolene, alcohol, kerosene, or other hydrocarbon per H.P. per hour for engineering and scientific purposes.

The ordinary motorist, however, calculates the quantity of fuel in relation to distance; that is, he finds by experience how far one gallon of fuel will carry the car on an average. The amount of fuel consumed will, of course, vary in accordance with the nature of the road over which the car is traveling, and the skill of the driver. The subject is further dealt with under Economizing Fuel. Also see under Compression.

The consumption of gasolene in city driving is high (sometimes amounting to double the amount used in give-

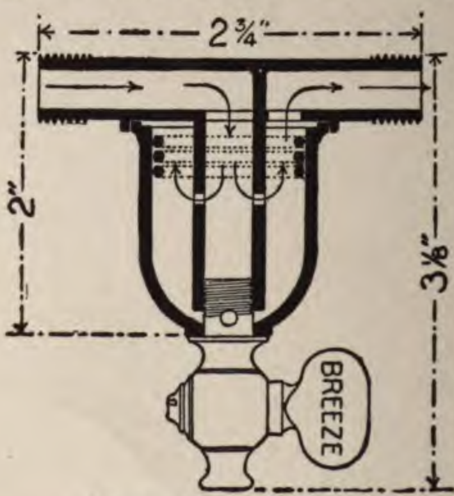
and-take country touring) owing to the frequent stoppages, restarts, and crawling behind slow vehicles.

To keep fuel consumption down, care should be taken to see that—

1. The compression is good (tight valves and rings).
2. The ignition is thorough (hot spark).
3. The ignition is accurately timed on all cylinders.
4. The driving is effected on the throttle, with the ignition kept well advanced, but short of knocking.
5. The cams are not worn or out of time.
6. The bearings are free (ball bearings), or if not balls or rollers, all bearings carefully lubricated and working parts in line.
7. The tires are kept pumped up hard.
8. Non-skids are removed in dry weather.

Fuel, Quality of—See under Loss of Power.

Fuel Strainer—An excellent way to save trouble and be sure

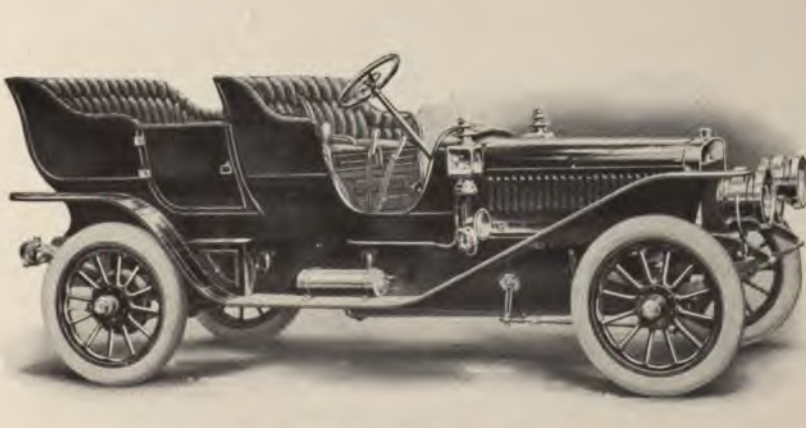


The Breeze Fuel Strainer.

of the engine getting a regular supply of fuel is to install a good strainer of generous size right close up to the carbureter.

The sectional cut shows the construction of a modern strain-

The Schebler Fuel Strainer.



The 1909 Six-Cylinder Winton.

er. To take apart and clean the strainer, unscrew the drain-cock. Occasional draining is all that is necessary under ordinary conditions to let the dirt and water out.

The fuel to be strained runs up-hill through fine meshed gauze, under which is a pocket for dirt and water to settle in and be drained out occasionally. It saves time as often as it traps the drop of water or eliminates the little piece of dirt that would interfere with the working of a carbureter.

There is no carbureter float-feed mechanism made that is not liable to flood if dirt gets under the valve seat. The only safe scheme is to use a strainer as close to the carbureter as it can be put.

To strain gasolene into a tank is good and very necessary, but tanks sweat and collect moisture and they sometimes rust. Galvanizing and solder chip off and vibration loosens dirt in the fuel pipe.

Fulcrum—The point about which a lever turns in lifting a body.

Fuller's Earth—A kind of earth composed of clay and silicious material, either natural or artificial; used by fullers for taking grease out of cloth and for various cleaning and drying purposes by automobilists.

Fumes, Exhaust—The fumes arising from the exhaust outlet should be avoided as much as possible. See Exhaust.

Funnel—A conical, wide-mouthed dish having an opening at the bottom of the cone. Used to fill up tanks having small filling orifices; sometimes known as a tundish. It is advisable to have special funnels for both gasolene and water, and each should be provided with a gauze strainer to arrest impurities.

The tube of the funnel should preferably have a notch or recess along its length to let air out when the fluid goes in.

Fur—The coat or crust formed on the interior of boilers, cylinders, etc., by matter deposited from hard water. Also called Scale.

Fuse—A tube filled with combustible matter or containing a composition that burns slowly and may be ignited by an

electric spark, etc.; used to set off explosives. Also a piece of metal of low resistance placed in a circuit to prevent damage from any sudden excess of current.

Fuse Wire—Same as Fuse in its electrical sense.

Fusibility—The quality of being fusible, or convertible from a solid to a liquid state by heat.

Fusible Metal—An alloy, usually of lead, tin and bismuth, compounded in such definite proportions as to melt at a given temperature.

Fusible Plug—A plug of fusible metal in the plate of a boiler, so placed that it will melt at a temperature too high for safety and allow the steam to escape freely; also, a plug that melts by heat of electrical resistance to guard against excess of current; also a plug in a system of waterpipes for fire protection of a building.

G

Gab—The hook on the eccentric rod of a steam engine which engages the rockshaft pin.

Gaiter, Tire—Same as Tire Sleeve, which see.

Gaiters, Motorists'—Protective coverings for the feet and ankles or for the whole lower leg; made of cloth, canvas, or leather, buttoned or laced.

Galvanic Battery—A kind of electric battery in which each cell is made of two elements (as zinc and copper), placed in a liquid (as a solution of chromic acid), whereby a current is produced when the metals are brought into contact externally; also called voltaic battery.

Galvanism is defined as that form of electricity arising from chemical action, more particularly from that accompanying the decomposition of metals; but it is a term not used in modern science. It was so called from the first investigator in the field, Luigi Galvani, professor of anatomy at Bologna, in the latter part of the 18th century.

Galvanic Cell—One of the unit cells of a galvanic battery.

Galvanize—To make use of electricity in treating the human body, iron, etc.

Galvanized Iron—Iron coated with zinc by galvanic deposition; or iron, usually in sheets, coated after cleaning by immersion in melted zinc. In the latter case electricity is not used and the name is in reality a misnomer.

Galvanometer—An instrument for detecting the existence and measuring the strength and direction of an electric current. It depends upon the force exerted between a magnetic needle and a wire carrying a current which tends to set the needle at right angles to the direction of the current.

Gantlets, Motorists'—See Gauntlets.

Gap—The distance, space, chasm or hiatus between two points; a break in a circuit; a breach of continuity.

Gap, Spark—The space between the points of a spark plug. See Spark Plug.

Garage—A word borrowed from the French, used to describe a place where motor vehicles are sold, repaired, or stored, and taken care of for a long or short time.

In the general adoption of this word from the French, the French pronunciation has been retained, as in the cognate cases of "chauffeur," "chassis," "tonneau," etc. A few bold spirits and persons of careless speech have Anglicized it in pronunciation as if spelled "gar-ej," with the accent on the first syllable, but the pronunciation generally preferred is the French "ga-razh," with the accent on the last syllable.

Garage Accessories—See under Tools, Spare Parts and Accessories.

Garage, Entering the—See under Driving.

Garage, Private—See Private Housing, under Care and Management.

Garnet-hinge—A kind of hinge resembling the letter T, laid horizontally.

Gas—One of the three recognized conditions of matter. An aeriform substance possessing the condition of perfect fluid elasticity, and presenting under a constant pressure a uniform rate of expansion for equal increments of temperature, but on reaching its maximum density behaving like a vapor. All gases can be condensed into liquids by cold and pressure.

In popular language, gas, or coal-gas, a mixture of gases used for lighting and heating. It is a form of carbureted hydrogen.

Gas, Air—Air forced through a mixture of hydrocarbons.

Gas-bag—A receptacle for gas used in certain gas lamps.

Gas Carbon—A hard form of carbon deposited in gas-making, used for electrodes, etc.

Gas Engine—Any motor which is actuated by the explosive force generated by the compression and subsequent ignition of gaseous compounds. Various hydrocarbons, as well as coal

gas and air, are used as fuel. For description of the form of gas engine commonly employed to operate motor cars, see Internal Combustion Engine.

Gas Engine, Cycle of—See Cycle, Otto; also Internal Combustion Engine.

Gas Engine, Diesel—See Diesel Engine.

Gas Engine, Efficiency of—See under Efficiency; also Compression.

Gas Engine, Four Cycle—See under Cycle; also Internal Combustion Engine.

Gas Engine, Two Cycle—See under Cycle, etc.

Gas Filter—A device containing a filtering medium fitted to acetylene lamps to intercept and decompose water coming over with the gas. See Acetylene Lamps, under Lamps.

Gas Producer—A furnace for the production of gas to be used as fuel.

Gases, Boyle's Law of—The theory that the volume of gases is inversely proportioned to the pressure, the temperature remaining the same. Vapors and the gases most easily liquefied deviate most widely from this law.

Gases, Gay Lussac's Law—The theory or law that, under a constant pressure, the volume of gas varies with the temperature in proportion to the change of temperature and the volume of gas at zero.

Gasket—A packing washer of asbestos, rubber, or other material used to make liquid, steam, or air-tight joints. Such packings placed between the flanges of a pipe are sometimes known as "gasket joints," and are also used in glands. See Gland, Joints.

Gaskets are frequently made of asbestos, and the softer metals.

Gasket, Cylinder Head—A blown-out gasket in the cylinder head will cause absence of sufficient mixture and loss of compression. See Repairs and Adjustments.

Gasolene—A light, volatile, colorless liquid commonly obtained by the distillation of petroleum and forming one of the series of hydrocarbons for motor cars. Much used as a fuel in internal combustion engines. Motor spirit is usually called "Petrol" in the British Isles, "Essence" in France (short for "Essence de pétrole"), "Benzin" in Germany, "Benzina" in Italy, etc.

When the crude petroleum, as drawn from the wells, is placed in a closed vessel and heated, the most volatile parts evaporate first. This vapor is caught and cooled (the combination of the boiler and condensing apparatus constitute a still), and the liquids which settle in the condenser come over, and have a specific gravity varying from 0.629 to 0.667 in the case of gasolene; to 0.802 for kerosene, and 0.875 for lubricating oils. Other petroleum products include cymogene, sp. gr. 0.588, naphtha, benzine, etc.

Gasolene is the first distillation before kerosene, that is, gasolene is a mixture of petroleum ether and benzoline. Chemically speaking, it consists to the extent of 75 per cent, or more, of methanes with some heptanes. The remainder is ethenes with traces of benzines.

Benzine is the unfortunate commercial name given to "A" naphtha, which tends to confusion with another substance which is a coal-tar product.

In ordering gasolene in Europe the scale often used for indicating the density is that of Beaumé. Zero on this scale corresponds to the density of a solution of salt of specified proportions, and ten degrees corresponds to the density of distilled water at a specified temperature or to a specific gravity of unity. The portion of the stem of the instrument lying between these two points is divided into ten equal parts, and the rest of the stem is divided into divisions of equal size up to ninety degrees. Higher numbers indicate lower specific gravities—a rather confused arrangement.

The actual instrument used is a densimeter or hydrometer.

The specific gravity of what is sometimes called .680 gasolene varies with temperature, but is supposed to be measured

at 60°Fahrenheit. It is .667 at 87°F., and .693 at the freezing point, 32°F.

Vaporization Experiments—The vaporization of gasolene requires a surface per H.P. of 221 square centimeters, heated to about 82° C., the pressure of the vapor mixture being 760 millimeters of mercury. The gasolene must fall on the surface drop by drop. In the case of spraying carbureters, the velocity of the air must be 25 meters per second; the vaporization surface can thus be less than 221 square centimeters. The vapor diffuses in air with a velocity of 5 millimeters per second. Knowing the speed of the suction, it is easy to calculate the openings in the gauze required and the length of suction pipe in order that the gasolene vapor may have time to completely penetrate the air before it is admitted to the cylinder. The vaporization of kerosene requires a surface of 200 square centimeters per H.P. heated to a temperature of 220° C., the pressure being 760 millimeters of mercury.

See remarks concerning gasolene under the headings Internal Combustion Engine; Carbureter; Driving; Care and Maintenance; Ignition; Cleaning; Involuntary Stops, etc. Also see Gasolene, Stale, below.

A Cheap Gasolene Gauge.

A very efficient and cheap form of gasolene gauge can be fashioned from a sufficient length of ground-glass rod, which should be fairly stout. Run your car on to a level place, empty your tank and then measure the gasolene back therein, gallon by gallon. After the introduction of each gallon sound the tank with the ground-glass rod and the height of the spirit therein will be plainly visible on the rod. Mark the height of each successive gallon on the rod with the edge of a sharp file, and, the rod being kept in a leather clip handy to the tank, you will have a ready means of determining how much gasolene there remains in your tank at any time.

Gasolene Leaks.

One often hears of abnormal gasolene consumption in certain cars, while sister cars are known to run far more eco-

nomically, and this is put down as a rule to the driver. To a great extent the gasolene consumption is under the control of the driver, but very often slight leaks in the gasolene system are responsible for a considerable amount of gasolene being wasted, and as the gasolene evaporates immediately, it is exposed to the air, these leaks escape notice, and the owner's pocket suffers accordingly. If a high consumption is experienced, and the ordinary remedies fail, we would suggest using a mixture of gasolene and kerosene, say, in proportions of one gallon of kerosene to four gallons of gasolene, when the kerosene will percolate through any leaks, but will not evaporate, thus rendering the locality of the leak easy to determine. As soon as the leaks are found out and repaired gasolene alone can be used again if desired. An alternative is to place in the gasolene tank a few grains of some aniline dye. This will color the gasolene, say, a dark blue, without affecting its qualities. The dyed gasolene will now pass through these leaks and leave a stain wherever a leak occurs.

It is a good plan to carry a length of rubber piping which nicely fits on the gasolene pipe from the tank to the carbureter. If the tank should ever leak seriously that rubber pipe can be put on one end on to the gasolene pipe. The other end, which has a short length of metal pipe, will be put through the cork of one of the two two-gallon cans of gasolene which should be always carried in the car, irrespective of what may be in the running tank, and by propping or holding up this can the driver will be able to get gasolene to the carbureter, and reach home or a place where the tank or its connections can be repaired.

Gasolene Supply.

When touring in remote districts, where gasolene supplies are infrequent, and where the quality is of a doubtful character, one naturally wishes to carry as large a supply of satisfactory spirit as possible. The storing of this, however, in two-gallon cans is inconvenient in many instances, as, no matter how neatly they are packed when starting out, they are

certain sooner or later to become dislodged, either for the purpose of removing baggage or obtaining spare parts, tools, etc., and they are never repacked as neatly as they were before. Even if they retain their original position, there is always the fear of their becoming upset through the vibration of the car when traveling. In many types of motor vehicles there is ample room for the placing of a tank in which may be carried any quantity of gasolene up to, say, twenty or thirty gallons. Generally these tanks should be located beneath the floorboards of the car, having a convenient filling cap on the outside of the car, or by lifting a floorboard in the back seats of the car. The cap should be perfectly airtight, and provided with an air pressure valve and permanent connections to the ordinary gasolene tank. When it is desired to replenish the latter, it would only be necessary to turn on the tap between the spare tank and the regular supply tank. Then, by means of the tire pump, sufficient pressure is raised in the spare tank to force the spirit from that into the second receptacle—an obviously easier and cleaner procedure than the unscrewing and filling up from cans, to say nothing of less waste, as the spare tank could be filled at a quicker rate than the ordinary tank. In addition to being much safer, this arrangement gives much more space for baggage, not to mention the passengers' feet and limbs.

For Straining Gasolene.

A Boston, Mass., automobilist contributes a good tip for the straining of gasolene before putting it into the tank. He says: "I have found the best quality (jewelers') chamois skin makes a most excellent medium for straining gasolene. It stops dirt, fluff and water, so far as my experience shows, and if the opening of the funnel is 8 inches in diameter, so that a good-sized piece of skin may be used, it does not materially delay the filling of the tank."

It is often a somewhat difficult matter to get car owners to realize the necessity for straining gasolene as it is poured into the supply tank of the car. Even men who have owned

cars for some time neglect this important though apparently small matter. They invariably start off by straining their gasolene, but sometimes when the strainer is not at hand they simply pour the contents into the supply tank from the can direct. Because nothing has happened they have continued this practice, with the result that they have got an accumulation of dirt which sooner or later reaches the carbureter, causing a great deal of trouble and annoyance before it is finally got rid of. Rather than fill up the tank with unstrained gasolene, it is better to use a pocket handkerchief folded twice or three times, or even four times, according to the texture of the material, and make a strainer of it. Of course, the handkerchief, after being employed in this way, is not desirable for personal use.

An Improved Gasolene Filter.

Another owner writes: "It has been my experience that gasolene is continually getting dirtier, and only during the past year or so have I had to clear my gasolene supply pipes on account of sluggish running, and I am (or rather was) surprised to find so much dirt. It occurred to me that a more efficient filter could be easily made to filter the spirit so perfectly that no solid matter or sediment could ever get into the tank. The following was adopted, and the arrangement has proven most satisfactory:

"Take an ordinary funnel, and remove (by melting the solder) the lower end. Buy a pepper dredger, knock the bottom out, and after straightening and cleaning the edges, solder this on to the top part of the original funnel.

"Enlarge by drilling small holes in the copper lid of the pepper-box, and your filter is complete when a small circular piece of linen is placed under the cover of the pepper-box. A supply of linen disks should be kept, for I find that a new one is required for filtering each can of gasolene."

Auxiliary Gasolene Tank for Touring Purposes.

Where gravity feed is used for the gasolene supply to the carbureter, the gasolene tank is often fitted as high as possi-

ble under the driver's seat, this giving just about sufficient head of gasolene to allow of satisfactory working on ordinary give-and-take roads. However, when touring through hilly districts, it is found that at times there is difficulty in maintaining the proper gasolene feed to the carbureter, so that just at the time when most gasolene is needed less is obtained. To get over this difficulty, a spare tank can be fitted at the forward end of the car, and connected to the carbureter, so that the fact of having hill-climbing to do would allow of really a higher head of gasolene to be supplied to the carbureter, so that no difficulty in climbing the worst of hills can be caused by failure of the gasolene supply to the carbureter.

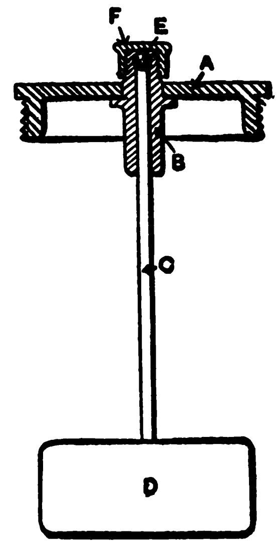
On Repairing Gasolene Tanks.

Should a tank or other vessel which has contained gasolene require repairs calling for a soldering iron, great care should be taken to clear such tank of any gasolene fumes which may remain therein, otherwise there is the possibility of an explosion occurring. Gasolene fumes being heavier than air will remain in any vessel for a considerable time, even though it has an opening to the air. There are several ways of clearing away such fumes, of which turning the tank with its opening to the lowest point and leaving it so for several hours is the easiest. Another method is to subject the tank to indirect heat in a similar position to that mentioned; that is, perhaps, the quickest method, though not always convenient. In any case, it is always advisable to keep it, if a blow lamp is used, as far away from the tank as possible.

Fitting a Float to a Tank.

Every driver feels the need of a float for showing the height of the gasolene in the tank, though only the most modern cars are so fitted. We show a simple method of fitting a float to any tank without cutting the tank open. The ordinary filling cap A is removed, and centrally in it is made a hole. Through this hole is passed a nipple B, which is soldered in place. The nipple is formed with a shoulder providing suitable holding

surface for the solder in spite of the usual thinness of the filling cap. Through this nipple B is passed a wire C attached to a float D. Replacing the filling cap, the float will rise, and the wire passing through the nipple will indicate how much fuel there is in the tank. Generally speaking, it is advisable to make the float to withdraw from the tank with the filling cap. For this purpose the end of the wire can be riveted over, or provided with a ball, as shown at E. On the top of the nipple is screwed a cap F, which normally keeps the



float down. Directly the small cap F is removed, the float will rise. Of course, the float D is made sufficiently small to pass through the ordinary filling opening, and care must be taken not to damage the float when the cap A is removed. In making a float suitable for the purpose, it is advisable to test its buoyancy in gasolene, after the wire C has been fixed. A float which is sufficiently buoyant in water is nothing like so buoyant in gasolene, and much time can be saved by first testing this point.

Gasolene Burner—A device for burning gasolene as fuel for

steam cars. A typical gasolene burner consists of a flat round chamber having a number of short air tubes running through it in an arrangement somewhat similar to that of the plugs in a boiler. Pinholes surround each air tube on top of the cylindrical chamber and the gasolene being admitted through an inlet or feed pipe running into the chamber and partly through it is mixed with air and escapes as a combustible mixture, to be ignited at the small pinholes through which it makes its exit from the chamber.

Gasolene Economy—See Economizing Gasolene; also under Driving.

Economy in consumption of fuel in any kind of engine consists in using just enough fuel for the purpose, and also, where the fuel is a combination of different elements, in using these elements combined in the cheapest way where one is of higher value than the other. Under the heading "Carbureter" we have dealt with proportions of gasolene to air. A great deal more air is required than gasolene. It has been found that a gas mixture in which there is too much gasolene not only reduces the power of the engine, but sets up internal troubles due to sooting up and overheating, so that if the proportion of air is too small, an extravagant proportion of the substance which has to be purchased is perforce being employed, and at the same time the engine efficiency is decreased and its mechanism injured.

This shows that the great and most important point as regards economy in consumption of gasolene is the proper designing and functioning of the carbureter. Under "Carbureter" we have described how attention is being drawn to correct design so as to obtain always a constant mixture, and also a mixture as efficient as possible. Generally speaking, the driver errs on the side of giving too much gasolene rather than too much air.

Another consideration is the speed of the engine. An engine will give out its greatest efficiency, that is to say, the heat units of fuel consumed will be least in proportion to the work done when the engine is running at the speed at which

it was designed to run. If it runs faster than this, it will be extravagant; if it runs slower it will require a richer mixture, and, therefore, a larger proportion of gasolene to air, and so in this instance also economical methods are not achieved. It is, therefore, advisable to run the engine as nearly as possible at a constant speed. In the case of an internal combustion engine as used on motor vehicles, however, this is practically impossible, but is approximated by means of the change speed gear.

The greatest economy in fuel can only be obtained by very careful driving and a thorough understanding of what is going on in the engine under varying circumstances. For this reason the reader should refer to the article on Driving, in which the manipulation of the control levers as regards air and throttle—in order to secure efficiency—is fully dealt with. He must bear in mind that the best results as regards speed and power obtained, and reduction in wear and tear of engine, will be achieved by practising economy; in other words, if he tries to force the engine by giving it a rich charge, he will not only fail to obtain the required result, but overheating, carbonizing, knocking, preignition, and many other troubles will soon make their presence evident.

Economy of gasolene, as it is generally understood by the automobilist, refers to economy in covering a certain distance. It is for this reason that in reliability trials the gasolene consumption is reckoned in ton miles, the speed being considered fairly constant for the car—that is, a speed of something about twenty miles per hour. Of course, the automobilist who averages over this speed will find that the consumption increases because the wind resistance, and, therefore, the power required to propel the vehicle on an even surface, increases as the square of the velocity.

This ton mileage method of arriving at economy also leaves out of consideration the nature of the roads and other resistances offered to the movement of the car, so that the economy will be affected adversely if excessively bad roads or heavy head winds are met with, or if the speed is high.

This method of regarding the subject precludes the fact that all these conditions make the engine do more work. Thus, if the engine is to be run economically, the driver must look to what is taking place in the engine and car itself. It is obvious that he cannot level out hills or smooth out roads or prevent head winds; it is also obvious that he can make the work which is actually done in the engine and car itself as small as possible, so that it is clear that economy will be affected if the engine is not in thorough working order.

Loss of compression will affect the power of the engine, but at the same time the engine will be using as much fuel, the result being that it will not propel the car the same distance, or against the same resistance, as it would if it were in proper working order, and thus economy in actual results is lost. In the same way the transmission mechanism (which includes the whole of the construction of the car which transmits the power from the engine to the road wheels), if it is not in proper order, will affect economy because it will absorb power, so that to perform the same amount of work as regards moving the car the engine will have to use more fuel.

The quality of the fuel used also bears on the question, although nowadays, with improved carbureters and a more uniform standard of specific gravity for gasolene, the condition of the fuel does not count for so much as it did in the old days. Another considerable loss of economy arises if the gas charge is not ignited and expanded at the proper moment; that is to say, the full length of the working stroke of the piston should be taken advantage of. It is obvious that if ignition of the gas charge is delayed until after the piston has commenced to descend on what should be the power stroke, a great deal of its efficiency will be lost as regards the pressure exerted on the piston. See Carbureter; Ignition.

Gasolene, Electricity and Steam, Comparative Advantages of—See under Electricity, etc.

Gasolene Engine—An engine or motor in which gasolene and air combine to form the explosive mixture. See under Internal Combustion Engine.

Gasolene Exhausted—See under Motor Stopping.

Gasolene, Extinguishing Burning—See under Extinguishing.

Gasolene Feed—The method of feeding gasolene to the carbureter either by gravity or under pressure. See Oil Feed.

Gasolene, Lack of—See under Loss of Power.

Gasolene Motor, Theory of—See under Internal Combustion Engine.

Gasolene Restricted—See under Motor Stopping.

Gasolene, Stale—This term is applied to gasolene when its density has reached a point which interferes with its free evaporation.

Gasolene becomes stale by the evaporation of the lighter part of the spirit, and the consequent increase of density in the remaining portion. The formation of the crude petroleum from which the gasolene is produced is such that by distillation a number of hydrocarbons of varying density are obtained, ranging from light spirit, which will quickly evaporate in air, to semi-solids and solids. The temperatures at which these different hydrocarbons are distilled over depend on their densities, and on their densities depend, to a great extent, their evaporative qualities.

Gasolene is made up of several hydrocarbons of various densities, some being above and others below the average density. Evaporation has a selective action, causing those of lowest densities to pass off first. In gravity-fed cars, where the tank has to have an air inlet to prevent the formation of a vacuum, evaporation takes place, as any exposure to the air allows evaporation and consequent increase of density, the heavier portion falling to the bottom of the tank, close to the outlet pipe.

As the density increases, the evaporative qualities lessen, and the spirit sprayed through the carbureter is not so easily taken up by the air, and the mechanical mixture formed is not so perfect. This imperfect mixture is much more difficult to ignite than one formed with fresh spirit, and consequently it is when starting a motor from cold that the objection to stale

spirit is most apparent. At this time the first spirit is a small residue left in the carbureter from the last time the car was driven, and in addition, this was the heaviest spirit in the tank at the conclusion of the run; so that the density will be found very much higher than that of fresh spirit, according to the time that has elapsed since the car was used.

It will considerably shorten the time taken to start if the stale gasolene is run out of the carbureter and fresh gasolene from the tank allowed to flow in. After the motor has run for a few minutes, all the parts begin to heat up, and a flow of hot air can be made to pass through the carbureter. Hot air, too, collects under the body and circulates round the gasolene tank, so that the temperature of the spirit is considerably raised. Stale spirit will not often interfere so much with either the starting or running of the motor.

As gasolene is an excellent thing for removing all grease and dirt from the metal parts of the motor car, and stale gasolene will answer as well as fresh, it is advisable to save for this purpose all the gasolene with too great a density for satisfactory evaporation.

Gasolene, Surplus of—See under Loss of Power.

Gasolene to Evaporate—See under Useful Information.

Gasolene Vehicles—See Motor Car.

Gasolene, Want of: Its Symptoms—See under Driving.

Gasometry—That department of chemical science which treats of the nature and properties of gases; the science, art or practice of measuring gases.

Gas Regulator—A gas governor or device for regulating the flow of gas for any purpose.

Gassing—The act of passing from a liquid to a gaseous or aeriform state, at the boiling point, etc.

Gate—In founding, (a) a channel or passage-way for molten metal; (b) the strip of waste metal left in the pouring hole. Also, a frame in which a saw is extended to prevent buckling

or bending. The slot or aperture through which a control lever passes in a system of gate control.

Gate Change—See under Change Speed Gear.

Gate Control—See Change Speed Gear.

Gate Quadrant—See under Quadrant.

Gate Valve—A valve with a sliding gate for closing and opening a pipe.

Gauge—An instrument for gauging or measuring gases, liquids, etc. There are many varieties, such as the following:

Steam Pressure Gauge—This denotes the pressure of steam within a boiler or other vessel. It has a dial and pointer, the dial being figured from 0 to 5, 10, 15, 20, and so on up to any required pressure. The figures represent so many pounds pressure to the square inch, and the intermediate pounds are denoted by strokes. A well known form is the Bourbon. The mechanism consists of a half coil of copper tube of oval section; the end of the tube is sealed and connected to a lever, the other end of which operates a toothed quadrant, gearing into a pinion on the pointer spindle. As the pressure increases the tube tends to straighten itself out and so gives motion to the quadrant, which in turn revolves the pointer, so indicating the pressure.

Air pressure gauge—An apparatus similar to the steam gauge. It is sometimes marked to give the pressure in pounds per square inch, but more often in atmospheres, one atmosphere equaling 15 lbs. per square inch.

Vacuum gauge—Similar to the air gauge, but denoting vacuum, or the power of suction. The figures read on the dial from 0 downwards.

Also spelled Gage.

The term is also applied to the bore or diameter of various things, as shotguns, wires, etc. Also to the width or distance between the rails of a railroad and the distance between the opposite wheels of a car. The standard gauge on American railroads is 4 feet 8½ inches.

Gauge, Air—An air pressure gauge. See Gauge above.

Gauge Cock—A stopcock which indicates the height of water in a boiler. See under Cock.

Gauge Collar—See under Gauge, Plug.

Gauge for Gasolene—A glass tube, etc., to indicate the height of gasolene in a supply tank. See under Gasolene.

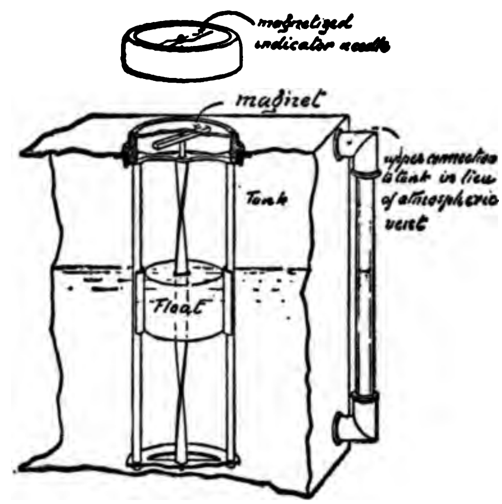
Gauge Glass—A glass tube connected to a boiler or tank to show the level of the contents. Used on steam cars having fire tube boilers to show the level of the water. In gasolene cars they are sometimes used to show the level of the gasolene and oil.

The usual form of gauge glass consists of a glass tube, plainly showing the level of the liquid. The glass is held in two elbow fittings at top and bottom by means of hexagonal gland nuts and is removed by unscrewing both these nuts.

A gasolene gauge is valuable in proportion as it is visible. A good dial form of indicator for the dashboard would be a desirable accessory to any car. To be of use it ought to show with some degree of accuracy the volume of the space which has been emptied of gasolene. Any gauge which only measures the level of the gasolene at one side of the tank is misleading, because the level is perpetually varying in accordance with the slope of the ground and the action of the springs. If we turn to the rough gasolene gauges which are available, the normal plan consists simply of a glass tube communicating with the bottom of the tank and fitted with a small aperture opening to the atmosphere at its upper extremity. Such a tube is little more than an index of whether the tank is one-quarter, one-half, or quite full. Owing to its being placed on or very close to the tank it is not in an easily visible position, and is rarely used by the driver when actually engaged in driving. A gauge of this class does not secure the user from occasionally starting out with little or no gasolene. The small vent to atmosphere provided at the top of the gauge is liable to get choked with dirt occasionally, so that it is possible to obtain an indication of a full quantity of gasolene on the gauge when there is almost none in the tank. Hence this type of

gauge should always be connected at its upper extremity to the upper part of the tank, thereby avoiding the need for a vent to atmosphere with its attendant small leakage of inflammable vapor. The gauge glass with vent to atmosphere cannot be fitted to any tank which is used under pressure.

The simplest of all gauges for a pressure tank is a graduated stick which is fastened to the screw-down cap of the gasolene



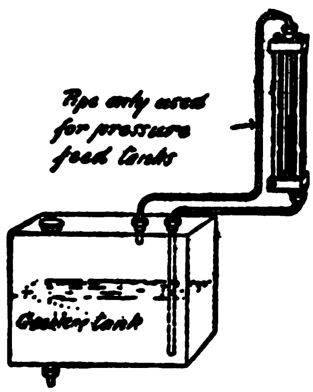
Two level indicators for Gasolene Tank.

inlet. When the cap is removed, the height to which the stick is wetted shows the gasolene level on the graduations.

This plan has the drawback that the pressure must be pumped up again after each reading.

Another ingenious form of approximate gauge is made on the following principle: A vertical strip of bronze twisted into a quick pitch screw-thread is pivoted at the top and bottom, and is caused to rotate by the rising or falling of a float which fits the screw-thread. The float itself is prevented from rotating by a pair of sliding guides. The whole system is inserted at the filling bung of the tank or near it through the top of the tank. The strip which has the screw-thread causes

a small index needle to rotate under a glass case. Such an arrangement should work very well, provided readings be taken only when the car is level. In practice it has the slight drawback that the glass is soon liable to become clouded by a deposit from the gasolene, which occasionally gets splashed into contact with it. If the screw and guides are not well and mechanically made, the float is liable to jam either in the up or down position, thus giving misleading readings. The instrument is no use for reading while the car is traveling, owing to the constant wash of the liquid in the tank. In an improved



A Gasolene Gauge for the Dashboard.

form, the needle instead of being directly connected to the rotating rod, is caused to rotate by the magnetic attraction of a small permanent magnet fixed to the top of the rotating rod. The merit of this is that the gasolene cannot be splashed on to the glass above the gauge.

Companies employing a number of vehicles for commercial purposes, such as parcels delivery, are so greatly interested in obtaining a minimum consumption of fuel, that an accurate gauge or gasolene meter which can be fitted on the dashboard, and which will read, say, to one-tenth of a gallon, unaffected by the level of a car or of its motion on the road, should have such a commercial success as to warrant the attention of inven-

tors. Steps in this direction have been made, as by a gauge and tank connection, which allows the gauge glass to be placed on the dashboard above or below the level of the liquid in the tank. It works on the diving-bell principle. The tube inserted in the middle of the tank is open at its lower extremity, and the height of gasolene in the tank produces a pressure within it which is communicated to the gauge, and then forces up a column of colored liquid.

Where a "pressure-fed" gasolene supply is used, the apparatus works equally well, provided the top of the tank is in communication by an additional small tube with the top of the gauge. In the absence of this tube the gauge, though useful, would appear to be only approximate, as there is no correction for expansion of the air by rise of temperature.

Gauge Lamp—A lamp by which a gauge or indicator is rendered visible by night.

Gauge, Plate—A gauge for determining with exactitude the thickness of metal plates.

Gauge, Plug—A gauge for testing internal diameters. A collar gauge is used for external diameters.

Gauge Point—In gauging, the diameter of a cylinder that is one inch in height and has a capacity equal to a unit of a given measure.

Gauge, Pressure—A gauge for determining steam or air pressure, as the pressure of the air in a pneumatic tire. See Manometer.

Gauge, Standard—A size that is recognized as standard; a gauge for determining whether tools, etc., are of recognized standard size.

Gauge, Steam—A steam pressure gauge. See Gauge above.

Gauge, Vacuum—See Gauge above.

Gauge, Water—A gauge for ascertaining the height or the pressure of water, as in a steam boiler or in a water-cooling system of forced circulation.

Gauge, Wire—A gauge for measuring the thickness of wire

and sheet metal. Usually a plate of steel with a series of notches of standard opening round the edge.

Gauntlets, Motorists'—Long stout gloves for use in driving and covering the lower part of the arm as well as the hand. Sometimes applied to the wrist-cover or cuff alone. See Clothing, etc.

Gauss—A unit used to measure the intensity of a magnetic field. It is the intensity produced by a magnetic pole of unit strength at a distance of one centimeter. Named after Karl Friedrich Gauss (1777 to 1855), a German mathematician noted for magnetic researches.

Gauze—A thin, slight, transparent fabric of open texture, as wire gauze.

Gauze Coverings, Choking of—See Causes of Overheating, under Engines.

Gauze in the Funnel—See Funnel.

Gauze, Wire—Wire cloth in which the wire is fine and the meshes very small. Used by motorists for filtering and straining purposes, etc. Fine mesh gauze has the property of preventing a flame from passing through it and may be used to inclose the flame of any lamp other than electric, which may be brought near to or under a car.

Gauzes, Air-Intake—Gauze coverings for the air inlet of a carbureter, to prevent the intrusion of dust and dirt.

Gauzes, Carbureter—See under Carbureter.

Gear or Gearing—A term often loosely applied to the transmission of a motor car generally, or to the change speed portion of the transmission. In its strictly accurate sense, it denotes any mechanism for transmitting power from one plane to another, and it is in this sense that we now deal with it. The descriptive matter which follows should be read in connection with Change Speed Gear, fully described in its alphabetical place.

Such transmission may be accomplished in many ways, but the principal methods which have been, and are, used at the

present time on motor cars are by —(1) Belt; (2) Chain; (3) Friction; (4) Spur (including various different types).

The reader must be careful to differentiate between "transmission" considered as a whole (dealt with under Transmission), and gear or "gearing" in its correct meaning. Two pulleys connected by an endless belt so that the one drives the other; two chain wheels engaging with a chain; two toothed wheels in mesh with each other; a screw in engagement with a wheel which forms an endless nut for it—all these variations constitute gearing, though not necessarily a transmission system in its entirety, or a change speed "gear." For example, an ordinary Panhard type change speed gear box consists of a combination of spur wheels, so arranged, however, that only two units of the combination are in mesh at one time. The two wheels in engagement, however, are, correctly speaking, the "gearing," and determine the ratio of the engine revolutions to those of the countershaft, or of the shaft to which the second wheel is fixed, irrespective of the rest of the combination in that position. The whole of the mechanism contained in the gear box is often loosely referred to as "the gearing," with a somewhat confusing generality that is misleading to the tyro when the term is used in its definite sense. The correct term in this particular case is the "Change Speed Gear or Gearing," and under this heading it is described elsewhere.

We shall now proceed to describe the different kinds of gearing under the heads already set down.

(1) Belt—Belt gearing consists simply of pulleys connected by an endless band or belt, and has been used largely in the transmission system of motor cars in the past, though such gearing is now obsolete. Belt gearing may be employed for transmitting power through parallel shafts, or by special arrangements from one shaft to another at an angle. See Change Speed Gear.

(2) Chain Gearing—This system can only be employed for transmission between two parallel shafts, and is largely used for conveying the power from the countershaft to the road wheels. Chains have also been used for change speed

gearing, and in some makes are at present fitted for conveying the power from the engine to the intermediate mechanism. See Chain; Transmission.

(3) Friction—This class of gear is chiefly found in use with progressive speed mechanism, whereby a friction wheel is pressed against the surface of a metal disk. The smaller member is driven by the engine shaft, and drives the disk by reason of the friction between the two.

(4) Spur or Toothed—The last broad heading includes several different species. The most common is the ordinary spur type, consisting of a series of teeth cut across the periphery of the wheel which engage with the teeth of another wheel. On the form of the teeth and their pitch, the silence, efficiency, and strength of the wheels depend. In making and designing spur wheels, an imaginary circle is taken called the "pitch circle," and the pitch circle of the other wheel is in contact with this, the ratio between the two wheels being known from the relative diameters of their pitch circles.

Each tooth is pitched at an exactly similar distance from the last, and the pitch is so arranged that a complete number of teeth are set out equally over the circumference. The precise distance of the center of one tooth to the center of the rest may be either stated directly, when it is known as the circumferential pitch, or as the diametral pitch. Diametral pitch is arranged so that the total number of teeth for a wheel of any diameter can be instantly ascertained, provided the diameter of the blank and the diametral pitch is known. For instance, if it is said that the diametral pitch is 8 and the pitch diameter of the wheel is 6 inches, the number of teeth will be 48.

Spiral Gearing—This type, which is used for the transmission of small power to a shaft set at an angle to the driving shaft, also has oblique teeth following a helical path, and the pitch of the helices is so arranged that the sum of the angles the screw teeth make across the faces of the wheels at any point is the angle at which the power has to be transmitted.

The wheels approximate to many threaded worms rather

than spur gearing, though the shape of the teeth follows an involute curve. These wheels are used largely in automobile practice for driving long shafts for the valve operation from the top of the cylinder, and run smoothly and silently, but the wear is rather heavy, and the end thrust set up, together with the sliding contacts between the teeth, render them unsuited for heavy power transmission.

Helical Gearing—Helical gearing is coming into use in motor car gearing owing to its smoothness of running and the small friction loss entailed by its use. With a helical gear each tooth forms part of a screw thread or spiral of very great pitch, and its formation makes it cross the face of the wheel diagonally. The fundamental idea is that the faces and flanks of the teeth come into and part contact in a more even manner than with the ordinary square cut teeth.

The spiral setting, however, causes an end thrust, and with a view to its elimination double helical or herring-bone gears are made. Double helical wheels consist of two ordinary helicals with oppositely cut teeth, clamped together so that the teeth correspond along the center of the wheel. With this arrangement the teeth appear to be V-shaped, with the point of the V in the center of the wheel. The right-hand section of the tooth sets up a thrust in a left-hand direction, and vice versa, so that end thrust is entirely absent. Gears of this type cannot be slid in or out of gear, and are only applicable for unvarying relative positions. They run very much more smoothly than ordinary spur gears, and give an even, silent drive, but they are expensive to cut.

Worm Gearing—Used in the steering apparatus because of its irreversibility, and in some cars for the transmission of the engine power to the live axle. Worm gearing has long been generally used for converting a high to a low speed for heavy mechanism or for very light work. Lately, however, improvements in the cutting machinery and experience of the type have rendered it capable of a much larger scope. The thread of a worm consists, of course, of a screw, which meshes with the female teeth cut into the worm wheel, and the ratio

of the gear depends on the pitch of the screw. Where a high ratio is necessary the worm may have any number of threads cut on it at intervals around its circumference to enable the high pitch to be used. For instance, a 4-inch pitch worm would require to be of enormous diameter and depth were this to be cut right away, but by making four starts, equally pitched around the circumference, and cutting four separate threads, each having a pitch of four inches, the same result is attained, with an immense reduction of size and increase of efficiency.

The number of independent threads may be increased within certain limits and depends on the pitch of each thread and the diameter of the blank.

Worm gearing gives an absolutely silent, steady, and powerful drive, and the recent improvements have obviated the irreversible motion hitherto considered inseparable from a worm drive. Wherever worm gears are used considerable end thrust is transmitted along the axis of the worm wheel. This is generally taken by a ball thrust collar. See Bearings; Thrust.

Bevel Gearing—This is the most usual method employed for transmitting power from one direction to another at an angle. The faces of the wheels are conical, and so arranged that the sum of their base angle make up the angle at which the power is to be transmitted. The teeth are cut on these coned faces, converging to the imaginary apex of the cone. The shape of the teeth may follow either of the ordinary forms, and may be either straight, helical, or double helical. The first only are capable of being cut from the solid, and so are the only ones generally used. The defects of bevel transmission are: (1) end thrust on the bearings; (2) loss through transmission at an angle. Bevel gearing is, however, very largely used in the construction of automobiles, and when well made forms an efficient drive. See Wheels.

Gear, Annular—A gear wheel having its cogs on the internal perimeter.

Gear, Balance—See Balance Gear.

Gear, Belt—Gear for the transmission of power or motion by means of a belt.

Gear, Bevel—Wheel work in which the cogs stand at an oblique angle to the shaft. Such wheels are often called conical wheels.

Gear Box—The box or case in which the change speed gears are incased. See Gear Case.

Gear-box, Cleaning the—See under Cleaning Motor and Machinery Parts.

Gear-box Protection—See under Care and Maintenance.

Gear Brake—The gear brake usually consists of a drum fitted to one of the rotating parts and adapted to be gripped by a band or shaped blocks; as the brake operates through the reducing gear it is more powerful than if fitted directly to the road wheels.

Gear, Cam—A wheel or wheels used to drive a camshaft.

Gear Case—A case which contains gearing of any description. The term sometimes refers to a light metal case which incloses the driving chain or chains, protecting them from dust and dirt, and which at the same time provides them with a lubricant. It also describes the box containing the change speed gears. See Change Speed Gear.

Gear, Change Speed—A gear device whereby variable speeds of a motor car can be secured while the speed of the engine and countershaft remains constant. See Change Speed Gear.

To a certain extent variable speeds can be secured on a level road without slipping the clutch or altering the gear, solely by means of the so-called "flexibility" of the engine, the driver having merely to close the throttle and retard the spark to attain to the slowest speed.

A car with a 16 to 20 H.P. engine can, without employing any of the changes of gears provided in the gear-box, start from rest on the level and pass through all the ranges of speed up to 30 miles per hour. There has been perhaps 3,500 pounds, total weight, in each case, and yet with favorable

winds up to 35 miles per hour has been touched on the same gear. This was done, moreover, without "slipping the clutch" save during the first 50 yards of the start. Nevertheless the gears are essential, and here is the reason: A 20 H.P. engine can only give 20 H.P. at or about one particular speed of rotation, say 900 revolutions per minute, corresponding to a road speed of, let us say 24 miles per hour on the "direct" or top gear. At all less speeds it develops less horse-power. Now in practice in the course of every journey it is found that the full power is desired at moments when the engine cannot attain 900 revolutions per minute on the top gear because the work is too heavy for it. Slowing of the engine from this cause occurs at every moderate hill.

The moderate hill can be surmounted at say, 10 miles per hour, but when effecting this the engine is not working at 20 H.P. It is working at half-speed and therefore at about half-power, say at 10 H.P. If we could relieve the engine so that it might rotate more rapidly and give 20 H.P., we could evidently travel faster than 10 miles per hour. It is to give this relief to the engine while the car is traveling that the change gear is introduced.

Further, if we reach a really steep pitch, say a hill rising one foot in every 6 feet, the engine would be stopped altogether unless an even greater change of gear ratio were available. There are few gasolene cars made under 60 H.P. which will climb 1 in 6 on top gear unless the top gear is so slow at its maximum rate of traveling as to be unpractical and very wasteful of fuel. The usual number of changes provided is three and sometimes four, besides reverse. See Change Speed Gear under Change.

Direct Drive—it is recognized that an improvement in efficiency and in silence on top gear can be secured if it is possible to eliminate one pair of gear wheels. We then get the result shown in Fig. 1.

It is not that less wheels are supplied in making the direct drive gear-box, for on the contrary it will be found that there is one more wheel, but when the claw clutch or dog clutch

shown in Fig. 1 is in engagement none of the other gear wheels are being used to transmit any power. They are all rotating idly and therefore silently.

It is as well to realize that the direct drive plan involves a less efficient transmission on all the gear ratios other than the top. See the last paragraph in the article on Gear Efficiency.

In the ordinary gear wheel sliding type of variable speeds on "second gear" or "first gear," four gear wheels must be in mesh in each case, whereas in the direct drive gear-box Fig. 1 shows that in no case (except reverse) are more than two gear wheels in mesh.

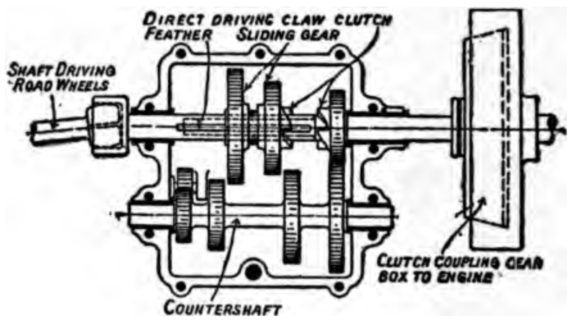


Fig. 1—Diagram of Gear Box showing three speeds forward and reverse with direct drive.

The reverse employs three gear wheels in mesh in both cases, so that there is no superiority on either side.

Both systems are in use on various cars, as is a third, which arranges that even the idle rotation of the driven gear wheels is avoided.

This third plan has, however, a certain drawback in the fact that when the driver is compelled to change to his lower gears he has a slightly more difficult task, namely, to thread into one another the teeth of two pairs of wheels simultaneously.

Other Drives—Many earnest attempts are being made to displace entirely the expensive mechanism of the gear-box, and these efforts will probably be crowned some day with success. The methods of attack of the problem are numerous:

(1) Belts (almost abandoned).

(2) Friction disks, from which the drive can be taken at any point of a diameter (experimental stage).

(3) Epicyclic gear.

(4) Idle pinions clutched when wanted.

(5) Idle pinions keyed by a sliding key when wanted.

(6) Electric transmission, as the "Auto-mixte."

(7) Infinitely variable gears by altering the "throw" of a crank or by varying the duration of time during which the power is transmitted.

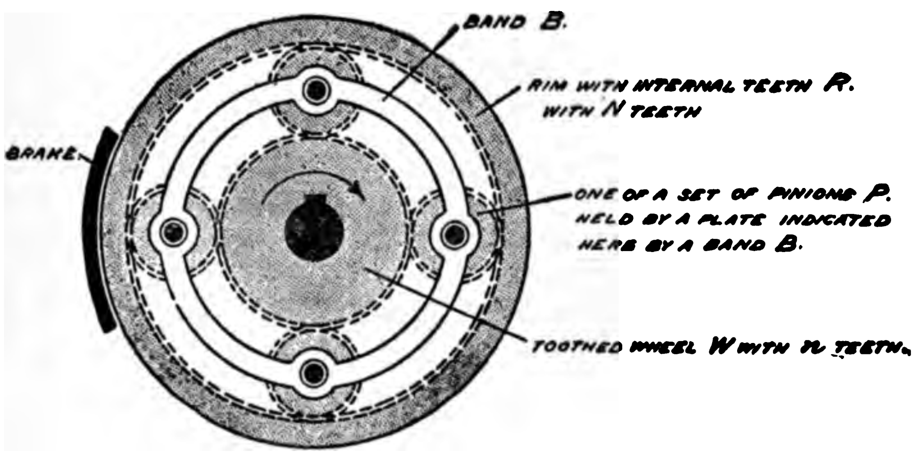


Fig. 2—Diagram of Epicyclic or Crypto Gear.

Epicyclic Gear—The teeth are arranged to be always in mesh and to run idle when not transmitting power, except on the top speed, when the whole of the gear turns together as one piece. There are then no losses from the running of idle pinions, and the weight of the gear acts as a flywheel.

Any one possessing such gear will find it worth while to have thoroughly understood it at once, even though he afterward forget the details.

If the inner wheel W (Fig. 2) be driven by the engine shaft, and the rim R be fixed by a brake, as shown in the figure, so that it cannot rotate, the band B, carrying the four

small pinions, finds itself obliged to rotate bodily in the same direction as the inner wheel W, but at a much slower speed. The band B may be replaced by a circular plate, which is rigidly connected to the chain wheel, driving the road wheels of the car; when the brake shown is applied to the rim, the chain wheel rotates forward at the slow speed.

To calculate the speed at which the band B, and with it the chain wheel, rotates when we know the engine speed is easy:—

Add the number of teeth on W to the number of teeth on R and divide this into the number of teeth on R. This fraction gives the ratio of the speeds of the chain wheel (or the band B) to the engine shaft, which is usually keyed to the toothed wheel W.

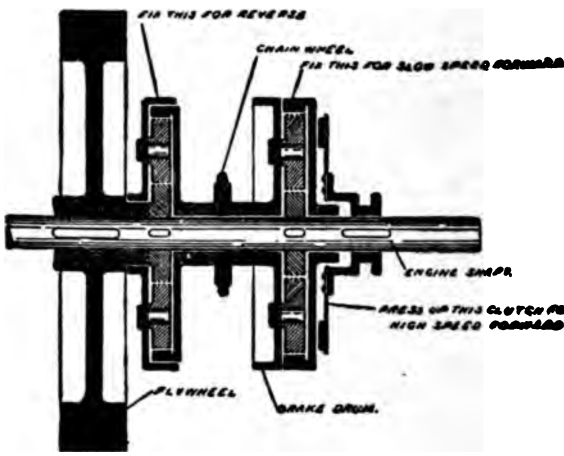


Fig. 3—Section of Epicyclic reverse and slow forward gear.

A neat example of utilizing this gear occurs on the earlier Oldsmobile and Cadillac cars, one of which is illustrated in section above (Fig. 3).

The third, fourth and sixth types of gear above noted are the most promising.

The flexibility of modern motor-car engines, and the normal employment of much larger horse-powers than formerly (12 H.P. meant a racing car some ten or twelve years ago) has

given a new lease of life to the stepped changes of gear. The gear is changed comparatively seldom, the tooth cutting is better, so that the noise is less, very superior gear steels have been found, and in many cases such a quality of steel is used that it does not require case-hardening, and therefore there is no warping of the metal.

Infinitely Variable Gear—This must not be dwelt on at length, as it is not yet in the commercial stage, but one type may be briefly explained. The ratchet or free-wheel type is exemplified by the Newman gear.

The engine shaft has an eccentric on it, and the amount of eccentricity is variable by hand. At each rotation the eccentric gives a to-and-fro motion to a free wheel on the rim of which is mounted a toothed wheel.

If the eccentricity is large, the to-and-fro movement is large, and the free wheel gives a large angular movement to and fro, but in one direction the free wheel merely slips in the toothed rim. In the return direction it drives the toothed rim, and so propels the car. The difficulty is clearly to get a "free wheel" which will stand such frequent shocks.

Despite what has often been said to the contrary, the importance of an infinitely variable gear is enormous to the motorist, and it is very seriously to be regretted that the efforts made have not yet been more fully successful.

Magnetic Change Speed Gear—See The Auto-Mixte Gear, under Change Speed Gear.

Gear Changes, Engine Thumping at—See under Driving.

Gear Changing, Art of—See under Change Speed Gear.

Gear Changing, Epicyclic—See under Driving.

Gear Changing on Hill Climbs—See under Driving.

Gear Changing through a Gate—See Control of the Gear, under Change Speed Gear.

Gear, Clash—See Sliding Gear.

Gear, Cleaning the—See Cleaning Motor and Machinery Parts.

Gear, Compensating—Another name for balance or differential gear. See under Gear, Differential.

Gear, Conical—Same as Bevel Gear.

Gear Connections, Change Speed—See under Change Speed Gear.

Gear, Crypto—Same as Epicyclic Gear, which see.

Gear, Differential—A differential gear, sometimes called a "balance gear," is a simple device which is misunderstood by the average car user, partly because it is never very accessible, and partly because it is very difficult to describe on paper. A British writer says: "In 1827, some of the motor 'buses which profitably plied for hire about Cheltenham and in London, had each of their wheels fastened by a pin to a solid rod of iron which constituted the live back axle. In several of these 'buses the axle was driven by a chain, but none of them had a differential. It is instructive to learn what happened.

"When they wanted to turn a sharp corner, say to the right, it was noticed that the inner or right-hand wheel had to traverse a much shorter circular path than the outer or left-hand wheel, and consequently had to make less revolutions than the left wheel. But the axle, which was coupled rigidly to both wheels, opposed itself to this difference in the amount of rotation, and rendered it mechanically impossible for the two wheels to turn at different speeds. It therefore became the custom to stop the car at a sharp corner and pull out the pin which fixed one of the wheels to the axle (preferably the inner one on the curve). (See Blue Book of Committee Report on Steam Carriage on Roads, 1831.) On removal of the pin this wheel was then no longer a driving wheel and the axle could freely rotate inside its hub, while the outer wheel was driven by the engine as before, and traversed its longer circular path without difficulty.

"Provision was doubtless made to prevent the loose wheel from slipping off completely during this manoeuver. When the corner had been turned, the pin would, in the ordinary course, be reinstated, but it is in human nature to suppose that

the post-boy, to whom this particularly greasy job was intrusted, disliked it and shirked it, and was rewarded by finding that his motor 'bus proceeded along its journey just as well without the pin as with it.

"There was a drawback, however. The power of the engine under these circumstances was entirely transmitted by one road wheel, and on coming to hills this wheel would skid. The evidence before the Committee shows that these early motorists made a practice of stopping near the foot of steep hills to rake their fires and get up steam, thus affording an opportunity for replacing the pin.

"It is probable that turning to the right was easier than turning to the left when the right-hand pin was removed, but in neither case was the turning so hard as when one wheel had to be bodily scraped across the ground."

This plan of freeing one wheel foreshadowed the plan (employed a few years ago on very small cars and now being resuscitated) of employing a "free wheel clutch" on each of the back wheels of a car instead of a differential.

All this impresses the fact that every curve traced by a car requires the wheel on the outer side of that curve to rotate faster than it did when the car was going straight. The wheel on the inside of the curve obviously has to go slower so that in a conceivable case (on a very sharp curve) the inner wheel might have to be almost stationary (acting as a pivot) while the outside one would run round it in a circular path.

Nowadays, we recognize this fact, and to free the wheels from one another we cut the axle in two so that one half axle corresponds to one wheel and the other half to the other wheel. As both wheels must be driven, we mount a bevel wheel (A′ and B′ of Fig. 1) on each half axle, and allow a small portion of the axles to project so as to form a center for a very simple device (Fig. 2), which is placed between them. We drive that device round by means of a flat belt or a chain or propeller shaft, or indeed by any mechanical means, and the thing is done. We have chosen a flat leather belt in the

figure simply for convenience. (The propeller shaft arrangement will be shown later.)

This pulley has a hub or center which allows it to spin freely on the projecting pieces A and B of the cut axle of Fig. 1. From the hub three or four round spokes are used to support the belt pulley's rim.

Fig. I.—A Bevel Wheel fitted to each half axle.

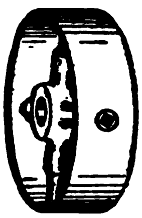


Fig. II.—Belt Pulley, arranged to run freely between the two bevel wheels A1 and B1 in Fig. I.

If it be put in position and driven by a belt from the engine it will not drag the two half shafts round with it unless at least one of its spokes is fitted with a small conical pinion C. To show this clearly Fig. 3 is drawn, which is Fig. 2 turned round a little more so as to disclose the bevel wheel. We shall not

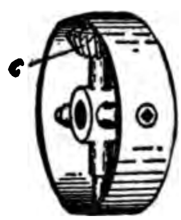


Fig. III.—Same Belt Pulley fitted with a conical pinion on one spoke.

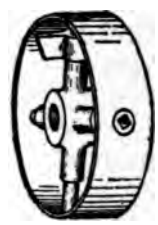


Fig. IV.—Same Belt Pulley fitted with pivot bar instead of pinion.

have to introduce another bevel wheel or pinion or mechanism or complication of any sort. We have, in fact, a complete differential or "balance gear" in this very simple system, and every other kind of differential in daily use, no matter how complicated in appearance, is the same as this and can be understood by having understood this.

When the belt pulley is turned round, it is clear that either (1) both half axles must turn, or (2) half axle A must turn, or (3) half axle B must go round.

If there is no friction, that is, if no one grasps either of the half axles in Fig. 1, both will rotate at the same speed as the belt pulley, so that the central pinion might just as well be replaced by a small pivoted iron bar as in Fig. 4. The ends of the iron bar are cut on the slope, so that they should fit between the teeth of the bevel wheels A and B, Fig. 1, and to prevent the bar from falling out, it is pivoted loosely on to one of the round pulley spokes, as shown.

The two arms of this iron bar are like the two equal arms of a balance. If there be equal pressure or equal resistance to motion on the two arms of a balance, whether this resistance be large or small, the balance arm does not turn. If there be an excess of resistance on one side, the bar turns or yields on that side. If we call the movement of the balance arm, on which there is the excess pressure, a backward movement, the arm on the other side moves forward by an equal amount, until, if the excess pressure continues, the balance arm slips out from between the teeth of the two-side bevels. This gives us the reason why a little pinion, as in Fig. 3, is used instead of a bar. Its action is exactly the same as the bar, but it has this advantage over the pivoted bar on the balance arm, that when a large "out-of-balance pressure" is exerted and maintained, another pair of teeth come into engagement with the teeth of bevel wheels A and B.

Let us now consider the whole appliance in action. When the car is traveling forward, driven by the belt pulley, the pressures on the two arms of the bar are equal to one another. When, however, the steering wheels are deflected to one side, it is clear without any mathematical demonstration that the car no longer rolls forward as easily as if all the wheels were pointing in the same direction as that in which the car is traveling. The steering wheels therefore introduce a resistance to forward motion, which may be slight or may be great, according to the amount of deviation from a straight course,

and this resistance is not the same on the two sides of the car. There is, in fact, a greater resistance to forward movement from that steering wheel which is on the inner side of the curve. On a motor car the steering gear is so contrived that whichever front wheel is the inner wheel (and therefore runs round the smaller radius of a curve) is always more deflected than the outer wheel. To a person who has never owned a motor car the same fact can easily be brought home by a simple experiment with any wagon or four-wheeled carriage. Turn the front wheels of the wagon round through a sharp angle, and then attempt to push the wagon by hand from the back wheels. First try pushing at a spoke of the inner back wheel, and then try pushing a spoke of the outer back wheel. It will be found that when the outer back wheel is being pushed the wagon is moved very much more easily.

In other words, an excess of resistance is offered by the inner back wheel, that is, the wheel which is on the inner side towards which the steering is deflected. If the belt pulley of Fig. 3 or Fig. 4 is driven round by the engine, exerting continually a certain effort, that effort is always, and under all circumstances, divided into exactly two equal parts by the balancing effect of the pinion (or the lever arm of Fig. 4), but whichever half axle offers the less resistance obviously turns more easily precisely in proportion as the resistance is less. So the differential gear performs its function, and drives the outer-driven wheel to turn more than the inner wheel, and this difference is the greater the sharper the curve.

A Second Explanation.

As one man's difficulty in understanding a mechanism is not the same as another's, so it may be useful to some readers to have a totally fresh and independent explanation from a different standpoint. Here are, therefore, two illustrations, and some very lucid text which originally appeared in The Horseless Age.

In Fig. 5 A and B are two racks—that is, straight, rectangular bars with teeth cut on them. These racks are rest-

ing on the floor and free to move vertically in guides. They are loaded down by weights W, W^1. Between the racks is interposed a pinion, which rotates round E, supported in the yoke D. If a lifting force be applied to the yoke D, in the direction of the arrow, and the weights W, W^1 be equal, as well as the weights of the two racks, and their friction in the guides, then the two racks will be lifted together and the pinion will not turn, but will remain in the same relative position to the racks.

If we add to the weight W^1 another, W^2, and again apply a lifting force to the yoke, then the resistance to motion of rack

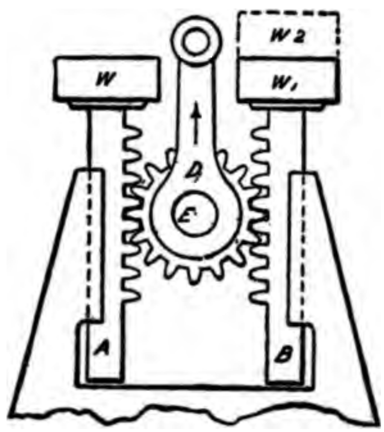


Fig. V.—Model to explain differential gear.

B being greater than the resistance of rack A, B will remain stationary. A will rise and the pinion will turn about its shaft E. This is under the supposition that the additional weight W^2 more than counterbalances the friction of the pinion at its shaft and at the teeth. We have then a differential motion, the same as in a differential gear, which is brought about by increasing the resistance to motion of one of the racks.

In a differential gear of the bevel gear type the two racks in the illustration (Fig. 5) are represented by the two side bevel gears (Fig. 6) and the pinion C is a bevel pinion, of which three or more are usually provided. The power is again

applied at the shaft of the pinion, to which in the figure a handle is shown attached, but which in practice is connected with a sprocket or chain wheel. As long as the resistance to motion of the two bevel wheels A and B is equal, the pinion C will not turn on its center D, but will simply rotate round the center of the shafts F and G, which are the two halves of the driving axle, and will carry the bevel wheels A and B along with it, the two (A and B) thus rotating at the same speed.

Now, suppose that the resistance to rotation of B becomes greater. This occurs when the steering wheels are turned to that side. Then pinion C will begin to revolve round its

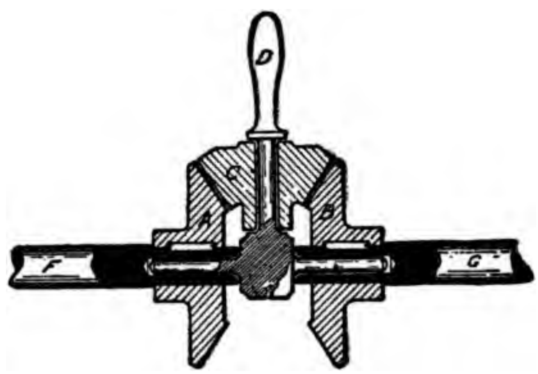


Fig. VI.—Model of Bevel Differential.

shaft and allow bevel wheel A to turn faster than bevel wheel B. These two bevel wheels are connected through the two half-axles to the driving wheels, and hence, if these bevel wheels turn at different speeds, the driving or road wheels do also.

In the crypto type of differential many makers utilize flat gear wheels instead of bevel wheels, because they can be more accurately cut, and from that point of view this form of differential is an advantage. Purchasers are prone to pay insufficient heed to the differential being of good make and free running. It is probable that if they realized what a difference a good differential may make to the life of the driving wheel tires, they would alter their attitude in this respect.

Although we have now described everything in a differential, we must not forget that in ordinary parlance the term is erroneously used to include a great deal more, namely, everything contained in the differential case.

If, in place of the belt drive employed in the example (Fig. 3), another mechanical drive, namely, a bevel drive, were used, the addition of the external bevel wheel and its pinion would lend to the gear the appearance of Fig. 4. But we must not be led to suppose that this driving gear is essentially part of the differential. It has nothing to do with it. It is merely placed in a case in close proximity to the differential. Lastly, it may be said that instead of one pinion C being

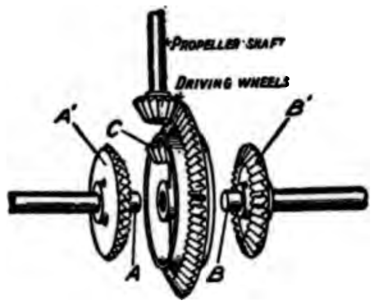


Fig. VII.—Complete Differential showing bevel, drive and pulley.

placed on only one spoke, it is usual to place two or three such pinions all performing exactly the same function on the other spokes, and further, if the drive shown in Fig. 7 is adopted, the side thrust due to this form of drive must be taken by thrust bearings, which are usually ball bearings. All these extra details are shown in the completed figure of an actual differential gear (Fig. 8).

Further Effects of the Differential—If the car be jacked up so that both driven wheels are clear of the ground and if the engine be run so as to drive the wheels round, they will turn at the same speed if they are equally free from friction and if the brake bands are clear. If now one wheel be stopped by hand, the other will be found to rotate at double the previous speed.

If the engine be stopped and the brake be applied to the propeller shaft so as to lock it, it will be found that if one of the driving wheels be turned forward by hand, the other wheel will rotate backward by a precisely equal amount, and at the same speed.

The knowledge of both these facts is important to the driver of a car because of its bearing upon the best way to avoid skidding, side-slipping, and indirectly the excessive wear of tires.

In the course of ordinary straightforward running the differential is always slightly in action, because the adhesion of the two driving wheels is never exactly the same. That is (1) owing to the uneven distribution of the weight of the passengers, or because the car itself never weighs exactly the

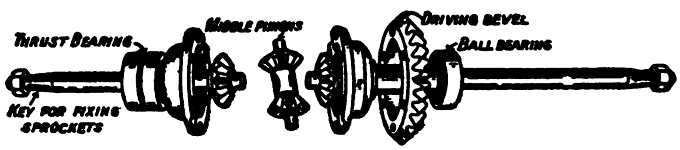


Fig. VIII.—Complete Differential as used on car.

same amount on both driving wheels; (2) owing to the surface of the road being invariably different to the two wheels to a slight degree. Thus either a road depression is under one wheel or an excrescence is under one wheel or a more slippery surface is under one wheel.

Now, no matter what difference of adhesion there may be between the two wheels and the ground, the differential provides that no more effort can be exerted on the wheel which has the more adhesion than on the wheel which has the least. Thus the forward effort on the car can never be more than that due to twice the smaller adhesion, and further as the efforts from the two wheels are always equal, the forward effort on the car is always applied to the car, as it were, from the center of the back (or driving) axle. If the wheels were keyed solidly to a solid axle without differential, the wheel which had the best adhesion with the ground would obviously transmit the larger part of the forward push, so that the result-

ant push or effort from both wheels would not be at the center of the back axle, but nearer to one side, the side of better adhesion.

This then is an advantage of the differential when the car is in use on the road in many cases, but in some of the situations which arise in the course of traveling by road, this very merit presents certain complementary disadvantages. Thus if, as often happens, one driving wheel has good adhesion, while the other is on very slippery ground, it is evident that the differential prevents the wheel which has good adhesion from driving the car forward with any better effect than if both wheels were on the same slippery piece.

The good adhesion of the wheel which is on good ground is, of course, capable of preventing side-slip of the car, but it is not capable of being utilized for forward propulsion beyond the amount which is possible to the other wheel on slippery ground.

In other words, a car which had a solid axle without differential should travel forward more quickly on a surface of which some parts were more slippery than others, because it would invariably be able to utilize to the full for forward effort whichever wheel presented the best adhesion, plus the small, but still not negligible effort on the other wheel. This advantage, and a certain superiority in avoiding side-slip, would also accrue to a car fitted with two "free wheels."

Also see article under Balance Gear.

Gear Drive—See under Change Speed Gear.

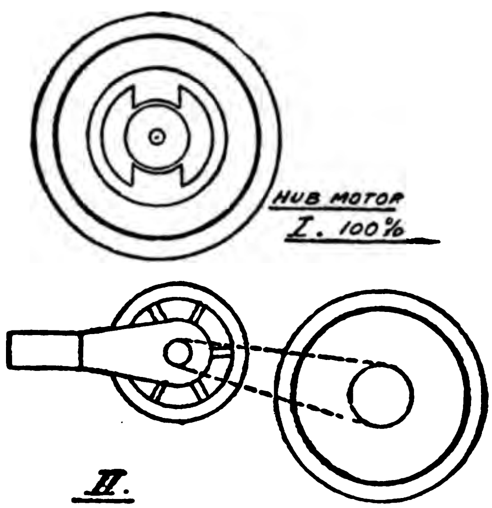
Gear Drive System, General Plan—See Transmission.

Gear Efficiency—See Mechanical Efficiency under Efficiency.

Users of cars cannot fail to be interested in the following figures of efficiency for various kinds of gear road wheels and tires. They are reported by a European authority from electrical experiments by Mr. R. Lacau.

"As an instrument of research electricity is invaluable in this as in every other industrial field, because it allows of the use of accurate measuring and recording instruments, which

eliminate personal error and enable a whole laboratory to be transported readily to the scene of the test, even on a motor car. One of the most striking results thus measured is perhaps the high efficiency established for a well greased roller chain in spite of its exposure to air and dust. Ninety-four per cent of the energy put into a roller chain in actual use on a car re-appeared as energy on the back sprocket, and whereas a pair of steel spur wheels similarly exposed only returned 90 per cent. These were the figures for new apparatus. When

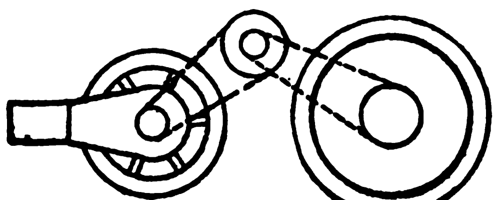


I. The most efficient drive. No gear reduction. Electric motor on the axle.
II. The second most efficient drive. One chain reduction. The motor and road wheels rotating in the same plane, 94 per cent. when new, 92 per cent. when worn.

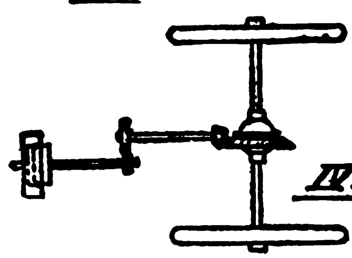
the chains were worn, the number fell to 92 per cent, but when the spur wheels were worn the number fell to 80 per cent, and this is where the important difference comes in from the point of view of the power. Spur wheels, it will be urged, are not generally run exposed to the dust and air, but in gear-boxes full of oil. Under this condition 92 per cent of the energy put into the first wheel was obtained from the second when all was new, and only 90 per cent when worn, so that even the new spur wheels cased in were only about

equal in efficiency to the worn roller chain exposed to the dust and air.

"It is not always, however, that a plain spur wheel is to be contrasted with a chain. It is sometimes the much less efficient apparatus, a bevel spur wheel, that must be compared, and such wheels well cased, running in oil and brand new, afforded 88 per cent, or when old 82 per cent efficiency only. The bevel wheel arrangement is in the case of many types of car associated inevitably with the Hooke coupling or universal



III.



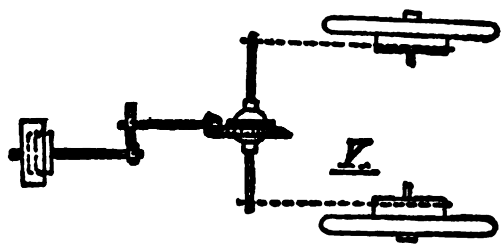
IV.

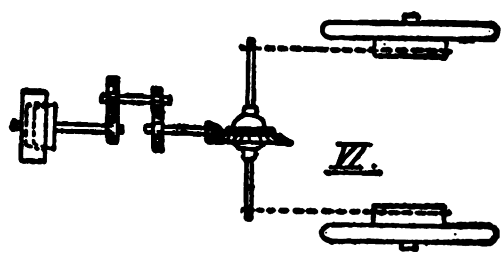
III. Two reductions of speed by chain, 88 per cent. when new, 84 per cent, when worn.
IV. " " " but power taken round a right angle, 79 per cent. when new, 65 per cent. when worn.

joint. It is not always appreciated that this ingenious device wastes power. It does not waste much, but even when new it does waste some, and if 100 H.P. is put in at one end of the shaft only 96 per cent can be got out at the other under ordinary road conditions. It will be understood in this, which appears like a tirade against bevel driven live axle cars, that nothing of the sort is intended. Such cars may, if well constructed, be far superior to certain, or even all existing chain-driven cars, but for the sake of the present investigation attention must be directed to one point at a time, and that one

point for the moment being efficiency of transmission, there is no question but that the chain is shown by experiment to be superior.

"In view of the great demand for very silent drives, even for auxiliary plant, such as pumps, magnets, etc., the steel pinion and fiber ring, and the rawhide pinion with cast iron rings have an interest, inasmuch as it is perfectly legitimate for an intending purchaser to ask himself whether he would





V. Three reductions of speed, one being right-angled drive, 74 per cent. when new, 69 per cent. when worn.
VI. Four reductions of speed, one being right-angled drive, 67 per cent. when new, 49 per cent. when worn.

prefer to consume a little more fuel and travel more quietly, and if that be all that enters into the problem he would probably consider it wise to prefer the quietude and pay the price. The efficiencies of these two silent combinations appear to be in both cases 88 per cent with new gear and about 80 per cent with worn.

"It must not, however, be assumed that because it is easier to make the fiber and rawhide combinations more silent than the plain steel ones, that in certain conditions it is not pos-

sible to approach to the same degree of quietude at a little more expense in the accurate gear cutting of steel wheels.

"Road Wheels—Many owners have believed the tractive resistance of solid tires to be less than that of pneumatics under certain conditions. Not having been able to bring anything but roughly approximate experiments to support the view they were glad to have Mr. Lacau's confirmation by experiment of a careful kind to show that on the electrical car on which the tests were taken at 13 miles an hour on good dry macadam, free from dust, the tractive pull per ton was 33 lbs. to 40 lbs. with solids; 44 lbs. to 53 lbs. with 90 mm. pneumatics; 53 lbs. to 62 lbs. with the same pneumatics partly inflated; and 64 lbs. to 71 lbs. with 120 millimeter pneumatics on the same car."

Gear, Elliptical—Geared wheels of elliptical shape used to obtain a rotary motion at variable rates of speed.

Gear, Epicyclic—See under Gear or Gearing; also Change Speed Gear.

Gear, Expansion—In a steam engine, the parts of the mechanism that control the admission of the live steam from the boiler to the main valves and cylinder.

Gear, Friction—Wheels which catch, or bite, and produce motion by means of friction and not by teeth. With the view of increasing or diminishing the friction the wheels are made more or less V-shaped.

Gear, Helical—Gearing of a spiral form. See under Gear or Gearing.

Gear, Herring-bone—A double helical gear. See Helical Gearing under Gear or Gearing.

Gear, High—The term generally used to describe the highest gear in a change speed gear system.

Gear, Idler—A gear or wheel placed between two others to transfer motion from one axis to another without change of direction. Also called Intermediate Gear.

Gear, Intermediate—See Gear, Idler, above.

Gear, Internal—Same as Annular Gear. See under Gear.

Gear, Jack-in-the-Box—A system of toothed-wheel mechanism which secures the rotation of a wheel on an axis which simultaneously moves radially round a fixed center.

Gear Missing in Speed Changes—See under Driving.

Gear, Miter—Same as Bevel Gear. See under Gear; also under Wheels.

Gear, Nest—A connected set or group of cogwheels and pulleys, often inclosed.

Gear Pinion—See under Wheels.

Gear, Planetary, or Planet Gearing—A system of gearing in which planet-wheels are introduced—that is, a set of epicyclic wheels for producing a variably angular motion. The usual device for this purpose consists of two elliptical wheels connected by teeth in gear with each other and revolving on their foci.

Gear Pump—See under Pumps.

Gear, Rack—In gearing, a toothed bar the pitch-line of which is straight, adapted to work into the teeth of a wheel for the purpose of changing rectilinear into circular motion or vice versa. This contrivance is called a rack and pinion, and the motion so imparted is rack-and-pinion motion.

Gear, Reversing—The mechanism by which the direction of the motion of a machine is changed. Generally speaking, the term covers all such parts of the machine, including the reverse lever, eccentrics, link-motion and valves of the cylinder. The change speed gear of the modern automobile includes provision for three or four forward speeds and reverse.

Gear, Roller—Gearing fitted with anti-friction rollers.

Gear, Running—The axles, wheels and connecting parts of a vehicle as distinguished from the body; any mechanism or working parts in distinction from the frame.

Gear, Segment—A form of gear extending over the arc only of a circle and intended to provide a reciprocating motion.

Gear Shaft—See under Shafts.

Gear, Silent—Gear made of material which renders it free from noise or sound in action; or gear made or matched so as to operate silently.

Gear, Skew—A form of bevel gearing for shafts lying at an angle to each other and in different planes.

Gear, Sliding—The form of gearing in which the toothed wheels slide into and out of connection along a shaft. Sometimes called Clash Gear. See Clutch.

Gear, Speed—The gear by which variable speeds are secured in an automobile. See Change Speed Gear; also Gear or Gearing.

Gear, Spiral—See Helical Gearing, under Gear or Gearing.

Gear, Spur—Gearing composed of spur wheels, the latter being the ordinary form of cogwheels. The cogs are radial and peripheral, and are adapted to engage countershaft cogs on another wheel. The pitch-lines of the driving and the driven wheels are in one plane. See Gear or Gearing.

Spur wheels or toothed gear wheels are liable to damage from the following causes:

(1) From being overloaded, or asked to transmit an effort greater than the engaging teeth are jointly strong enough to bear, for example, when a countershaft brake is used too violently.

(2) From being mounted on engaging wheels whose axles are badly aligned or at the wrong distance apart.

(3) From being badly cut, or cut to a bad profile.

(4) From being badly handled by the driver in one of four ways:

- (a) Allowed to drive when only in partial engagement.
- (b) Allowed to take up the drive with a blow or shock, instead of taking up the pressure gently.
- (c) Brutally forced into engagement.
- (d) Being neglected as to lubrication.

All these cases are really methods of obtaining an overload on the teeth.

Alignment—Thus in (2) the effect of bad alignment is that the whole pressure due to the transmitting the effort of the engine comes upon an edge of the teeth instead of acting upon the whole width, thus overloading the acting edge. Bad alignment after an overhaul in an amateurish repair shop is the most likely trouble, and one of the hardest for an unskilled owner to detect.

Meshing—It is fairly easy to know in a general way if spur wheels are not meshing properly, that is to say, in more technical terms, if the pitch circles are not touching one another. To begin with, the gear will be noisy. If the meshing be too

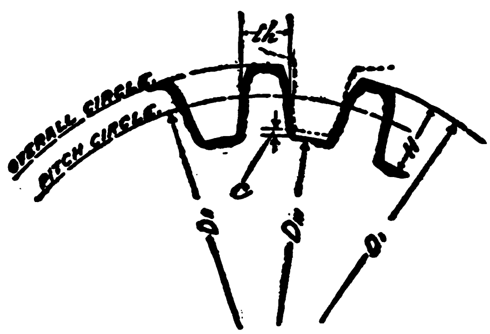


Fig. 1—Showing Overall and Pitch Circles.

deep the tips of the teeth on one wheel will penetrate so far into the spaces on the other wheel that the clearance marked C on Fig. 1 will not exist, and the ends of the teeth will be continually in compression. The obvious general rule, however, is this: Measure the distance between the centers of the engaging spur wheels and divide this into two lengths in the ratio of the number of teeth in each wheel. These two lengths are the radii of the pitch circles, and the pitch circles if described on the wheels would cut each tooth at a little outside of the middle of its engaging face. When two teeth are in full engagement, the line from center to center of the wheels passes through the point of contact of the teeth, and so do both the pitch circles. If teeth mesh badly, whether too

deeply or too little, there is rubbing and crushing of the surfaces and loss of efficiency, particularly with cycloidal teeth.

Shape of Teeth—In (3) the effect of a tooth being a bad shape is that even though the whole width of surface is operative the root or other part of the tooth has been made too thin for the pressure to be transmitted; it is therefore overloaded and snaps. Involute teeth are preferable to cycloidal in the gear-box.

Partial Engagement—In (4) if a careless driver leaves the speed lever in an intermediate position between the notches, or if the quadrant which carries the notches is strained over by rough usage, only a fraction of the width of the tooth is operative and overloading of that fraction occurs, so that either a piece chips off or the metal crushes and flows generally so as to make a burr on the edge of the tooth. If a piece chips off there is grave risk of much expensive damage resulting from the piece, even if quite small, getting jammed between another pair of teeth and snapping either one or other off. The freshly broken tooth may then chance to drop between two other wheels rotating in engagement, and it will ruin them also, whether or not they be transmitting any power. This possibility of damage being done to gear wheels which are rotating idly, by the accidental intrusion of foreign matter such as a flynut belonging to the lid of the box, is a slight drawback to the type of gear-box which employs such idly rotating wheels, apart from the objection to the noise and the waste of power. The latter, however, need not be important if the gear-box be fitted with ball or roller bearings.

Fierce Clutch let in badly—A cause of damaged gear wheels is sometimes the accident by which one's foot slips off the clutch pedal. If it be very fierce, and the engine running fast while the car is nearly stationary, a considerable jar results. It is true that the factor of safety, or the margin of strength of the teeth, ought to be sufficient to allow for all such eventualities as may legitimately occur to a careful driver, but the size and weight of parts is very closely cut in motor cars,

and the design is rightly made as close to the safe limit as possible. A slippery pedal should be roughed at an early opportunity.

Noisy Toothed Wheels—The teeth of gear wheels cannot be engaging each other properly if there is much noise. This incorrectness (if not in the original design) may be due:

(1) To warping.

(2) To wear.

(3) To bad alignment of the axes.

(4) To bad distancing of the wheel centers, especially with cycloidal teeth.

(5) To sliding wheels badly centered on a square shaft.

Warping takes place in manufacture during the process of hardening the surface of mild steel teeth. The expense of grinding teeth after they have been hardened is so great that it is often avoided by the maker, and the hardened teeth are matched with one another after hardening by the process of trial and error till a silent pair is found.

It is well to remember that silent gears on a new car are not necessarily a sign of perfection of the gears, because obviously if the hardening process has been simply omitted there will have been no warping, and the truly cut tooth profiles (machine cut with great accuracy in most cases) will not make any noise till the absence of hardening has been revealed by the rapid wear. As a test of hardening, one cannot cut the face of a hardened mild steel tooth with a file save with difficulty, and the roughness of the file gets polished in the attempt.

Latterly, and in some of the very finest cars, certain peculiar steels described under Steel are used, which are sufficiently hard in themselves, and very tough and strong. These steels do not require to be case-hardened, and though they have not got sufficient hardness to pass the file test they are well able to stand up against the wear of the gear-box.

This fact is mentioned to prevent conclusions being arrived at too hastily by the inexpert. In cases where legal action is being taken on the ground of alleged bad work and ma-

terials, analysis or full mechanical test should be made of the steel.

Noise of Gear Changing—The noise of gear changing must not be confused with the noise previously alluded to made by the gears after the change has been effected. Gear changing with "clash" gear of the sliding type is noisy when the sides of the teeth which have to be pushed past one another are not rounded off, or when the rounded sides have been bruised by the driver using too much force in effecting the change, or by the driver attempting to change without keeping the clutch pedal fully depressed.

Even when the clutch pedal is fully depressed it is important to remember that the light or inner part of the clutch has a certain inertia of its own and tends to continue revolving after it has left contact with the fly wheel. It is only when this movement has reached a certain value that the ideal condition for sliding the gear occurs. That condition occurs when the teeth which are coupled to the road wheels move at the same speed as the teeth which are driven round by the inertia of the clutch and are about to be thrust between them.

To facilitate the getting of this condition during the driving of the car a small brake pad is often arranged near the back of the clutch, so that when the clutch pedal is fully depressed the clutch cone (male part) comes into frictional contact with the brake pad.

A better arrangement still is provided by some designers, who make the male part of the clutch and the gears to which it is connected of such small size and light weight that they have but little inertia and therefore easily take up any speed or change of speed which may be impressed on them by the gear wheels they are lightly put into contact with.

Broken Toothed Wheel—If it is not convenient to get into touch with the maker of the car (as often happens when one is in a distant state) the correct replacement of a broken gear wheel is a difficult matter. It will be facilitated by sending to the best local gear cutter either a broken part or a "rubbing" on paper made from the profile of the tooth, provided

Gear, Starting—The devices by which an automobile engine is started. See under Driving, Control, etc.

Gear, Steering—See Steering Gear.

Gear, Stepped—A form of gearing in which each tooth on the face of a wheel is replaced by a series of smaller teeth arranged in steps; used to secure a more uniform and continuous bearing between the teeth.

Gear, Sun-and-Planet—See Gear, Planetary; also Epicyclic Gear, under Gear or Gearing.

Gear, Timing—See under Timing, also Ignition.

Gear, Two-to-one—The gear of a four-cycle engine which drives the camshaft. See under Engines, also Internal Combustion Engine.

Gear, Worm—A gear consisting of two cylinders set parallel to each other, with spiral ribs and grooves that mesh together.

Gearing—A train of toothed wheels for transmitting motion; the parts collectively by which mechanical motion is transmitted. See Gear or Gearing.

Gearing, Hooke's—A kind of gearing for wheels in which the teeth are cut in a helicoidal form. Named after Robert Hooke, English philosopher (1635-1703).

Gearing, Stepped—See Gear, Stepped.

Gear Protection—Automobilists whose engines and gearboxes are so exposed as to collect dirt and mud from the road will be well advised to fix a protecting sheet underneath. The best method of affording such protection is obviously a sheet aluminum apron, which can be attached in many instances to the frame of the car. There are, of course, some objections to this form of protection, as in the event of one having to get at the lower part of the crank chamber or gear-case for inspection or adjustment, it is necessary to remove the apron. This would entail the unbolting of this part, and thus add to the difficulties of the work in hand. Some owners of unprotected cars have adopted an excellent method of affording

The commonest kind contains about eight parts of copper, two of nickel and three to five of zinc.

Gib—A piece of iron used to clasp together the parts of wood or iron of a framing which is to be keyed.

In machinery, a fixed wedge used with the driving wedge or key to tighten the strap which holds the brasses at the end of a connecting rod. What is called a "gib-and-key" is a fastening to connect a bar and strap together by means of a slot common to both, in which an E-shaped gib with a beveled back is inserted and driven fast by a taper key.

Gill—Any part resembling the gill of a fish in form or function. One of the flanges, also called fins, placed for cooling purposes on certain forms of tubular radiator. See under Cooling.

Gilled Tube Radiator—See under Cooling.

Gimbal—A device allowing a suspended body to incline freely in any direction, commonly consisting of a ring pivoted so as to turn on a horizontal diameter and having the object pivoted in the ring on a diameter at right angles to the other.

Gimbal Joint—A form of universal joint on the plan of a gimbal.

Gimlet—A small spirally grooved tool having a pointed screw at the end used for boring holes in wood by turning.

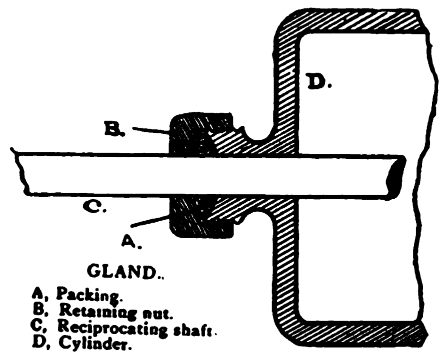
Girder—One of the two main lengthwise beams of a motor car frame or chassis.

Give—To yield, as to pressure. Also, the quality of yielding or capacity to give way; elasticity; as, the give of a car spring.

Gland or Stuffing Box—A device for making a water or gas tight joint around a rod, and to permit of reciprocating or rotary motion of same. The gland proper is the male part of the joint, and the stuffing box the female. The shape and mode of adjustment depend entirely on the size and pressure that the gland has to stand.

The end of the gland that enters the box is coned inward,

and the bottom of the box coned similarly. Between these tapered faces hemp, asbestos, cotton, or other suitable packing, well greased, is inserted so as to envelope the rod and completely fill the annular space. On tightening the gland the packing is compressed and forced inward so as to press tightly upon the rod. As a generality, the term denotes the



GLAND.
A, Packing.
B, Retaining nut.
C, Reciprocating shaft.
D, Cylinder.

joint as a whole and is understood to mean the complete device.

Gland Box—Same as Gland.

Gland-cock—A faucet kept in place by a gland which can be removed when it becomes necessary to get at the plug.

Glass Gauge—See Gauge.

Glass-paper—A polishing paper made by strewing finely powdered glass on a sheet of paper besmeared with a coat of thin glue.

Glass Screens—See Wind Screen.

Glass, Water—Same as Water Gauge. See under Gauge.

Glasses, Lamp, Cracking of—See under Lamps.

Glidden Tours—A series of annual experimental tours for motor cars. Named after Mr. Charles Jasper Glidden of Boston, Massachusetts, an enthusiastic motorist of international fame.

Globe Joint—A form of universal joint that will transmit rotary motion. See Joints.

Globe Valve—A valve having a casing practically globular in form.

Gloves—In driving an automobile a gauntleted glove is useful as keeping the draft out of one's sleeve, or a wristlet without the glove answers the purpose. There is also a leather glove with woolen wrist which is very warm and does not require buttoning.

Woolen gloves are well liked for comfort and for not becoming slippery when wet. On the other hand, they let the dirt through when handling tools. See Clothing, Dress, etc.

A pair of chamois leather gauntlets are the best things to wear when doing very dirty work, such as taking a link out of the chain. An old pair of kid gloves are best when the dirty work also requires the handling of fine parts.

Glue and Cement—Viscous substances for uniting pieces of wood, iron or other materials. Liquid glue is a glue kept in a liquid state by treatment with an acid.

Marine Glue—A glue made of equal parts of shellac and caoutchouc dissolved in separate portions of naphtha and then mixed. It is used in shipbuilding in making watertight joints and can also be used as a cement for rubber.

A Wood Glue—Boil together for three hours—glue, 100 parts; water, 260 parts; nitric acid, 16 parts.

A Cement for Iron—Mix together carefully—sulphur, 6 parts; white lead, 6 parts; borax, 1 part. Wet this mixture with commercial sulphuric acid before using and press together the iron surfaces between which it has been placed. Allow a week to set firm.

Liquid Glue for Wood and Iron—Gelatine, clear, 100 parts; good glue, 100 parts; methylated spirit, 25 parts; alum, 2 parts. Boil for three hours these ingredients in a mixture of water, 200 parts; acetic acid, 40 parts.

Cement to stand Acid and Heat—Melt together sulphur, 100 parts; tallow, 2 parts; resin, 2 parts. Add enough ground glass powder to make a paste. Use this cement hot.

Cement to join Glass and Metal—Pure gum arabic is dissolved to a syrup in water; well mix in finely crushed calomel (poison) to make a paste. Make as required, and allow three hours to harden—allow more time if possible.

Glycerine—A transparent, colorless, sweet liquid that forms the basis of fats. In chemistry it is glycerol, a triatomic alcohol. Used in automobiling in anti-freezing solutions. See under Anti-freezing.

Glycerine Solutions—See Anti-freezing Solutions.

Goggles—Spectacles used by motorists to protect the eyes. Those who are in the habit of wearing spectacles should have their goggles made with lenses the same as their ordinary spectacles, otherwise—particularly if their sight is very defective—they are likely to misjudge distances.

A motor car driver is seated very much nearer the road than the driver of almost every other vehicle, and he is consequently exposed more than anyone to dust, while he shares equally with others the annoyance of flies, wind and glare. As a protection from these, especially in the absence of screens, he is well advised to overlook the unsightliness of goggles, and to wear them faithfully throughout the drier months of the year.

In cities, when speeds are low, it is not usual to wear them, though this may be a mistake, in view of the objectionable character of the dust which is flung up by cab, carriage and wagon wheels as well as motor cars. During rain, or immediately after it, goggles are unnecessary.

It is generally thought advisable to have flat glasses, unless specially cut spectacles are habitually used for some defect of sight. Nevertheless a curved piece of very thin glass, with the two faces strictly parallel to one another along the curve, does not appear to be objectionable for the kind of use to which one's eyes are put in motoring, and such curved glasses make a much neater goggle.

Unless the glass fits very close up against the eye, it is necessary that it should reach to a point very near the nose

so as to prevent squinting; some glasses have a glass bridge extending right across the bridge of the nose. They are good, but very liable to be broken.

It is important for the driver, though not so much for the passengers in a car, to be able, without turning the head, to see out of the corners of his eye any approaching or overtaking vehicle, and for this reason many consider that if goggles are made with flat glasses side panels of glass are advisable.

To keep out flies and dust the rubber, leather or cloth mounting of goggles must fit very close to the face. If once a little dust gets under the leather flap of the goggles it gets rubbed into the tender skin about the cheeks and causes irritation. It is also quite remarkable what an amount of trouble small flies will take to discover the smallest joint in one's eye armor, and having found it to crawl in, and thereafter to buzz with frenzy in the attempt to escape again.

In rain a drop of glycerine on the glass is supposed to prevent raindrops from forming, but its use is not very successful. A rub of caustic potash on the outside of the glass is better, though it is well to keep this substance out of contact with the eye.

A popular form of goggles are made with curved glasses not much larger than spectacle glasses, mounted in a frame which fits the face by being edged with a pneumatic rubber tube. In this, ventilation is provided by means of minute tubes which lead fresh air into the space behind the goggle, as well as additional small tubes which lead hot air away without creating any perceptible draught.

A relief for tired eyes is to bathe them (that is, open them) in a saturated solution of boracic acid in lukewarm water; cold water is bad unless the eyes are hardy and accustomed to it, but cold water is better than nothing when the eyes are inflamed. A drop of tea freshly made, dropped into the eye by letting it run down the eyelash from the point of one's finger, acts as an astringent and if introduced overnight will generally banish the bloodshot appearance (which sometimes results from not wearing goggles) by the next morning.

The mist which forms in tight-fitting goggles under certain atmospheric conditions is almost unavoidable save by the use of quartz in lieu of glass.

The fatigue of the back of the ears with the pull of the wires is diminished by the use of thick rubber guards on the wires.

An eminent oculist points out that dust strictly so called is produced by breaking up the ground, and this is of mineral origin; but vegetable and animal substances (husks, straw, hay, remnants of various vegetables, etc.), micro-organisms and insects, are present, and these cause wounds or painful irritation.

Goggles should consist of: (1) Two frames fitting round the eyes; (2) a bridge; (3) two air chambers behind the glasses; (4) open-work surfaces at the sides for ventilation; (5) two suitable glasses; (6) as light as possible a mounting, fixed to the head by a simple device. Two essential conditions are: First, it must be possible to see without turning the head, equally well in all directions over the field of vision; secondly, the goggles must adapt themselves to the wearer's face. The weight should not exceed 50 to 60 grams. The parts in contact with the skin should be covered with chamois leather, to assure tightness, stability and soft contact. The nose bridge may be covered with leather. The air chamber should be about 2 centimeters from the inner side of the glasses to center of cornea. The open-work sides should be covered with copper gauze with meshes of 15-100 millimeters. The glasses may be smoked to protect the eyes, and be periscopic, that is, have an equal power in center and on circumference.

For ladies a not too hideous eye-shield is made of folded mica, arranged as a lining for the motor veil.

Gold, Aluminum—Same as Aluminum Bronze, an alloy of aluminum and copper, of a pale gold color, used for journal bearings and in boat-building, etc.

Gong—A stationary bell, in form resembling a round flat

dish; used for signaling and struck with a hammer operated mechanically.

Gong, Electric—A gong sounded by means of electricity.

Good Compression, How to Maintain—See under Compression.

Governing—Governing is a term used to describe various methods of regulating the speed of the engine, which need not necessarily, however, be accomplished by any of the many contrivances included under the general term "governor."

Flexibility, silence and economy in consumption have largely engrossed the attention of motor manufacturers of late years, and with most satisfactory results. In attaining these ends perfect control of the speed of the engine was the prime object aimed at, and to secure this perfect control the carbureter question had first to be tackled. The difficulty was a serious one. It was found that when the old type of carbureter was set to give a perfect mixture, say, at 800 revolutions, the mixture became richer as the speed increased, and weaker as it decreased, until in the latter case it reached a point when it became so attenuated as to be non-explosive. Consequently the engine lost its power very rapidly; it lacked flexibility, thus necessitating frequent changes of speed; and could not be made to run really slowly when idle.

This arose from a very simple cause. It takes a greater suction power, needless to say, to lift gasolene than air. As the speed of the engine falls off, the suction weakens, and, consequently, the proportion of air drawn in through the supplementary air inlet is increased, thus weakening the mixture until it reaches the non-explosive point. To remedy this defect many carbureters have been put on the market which automatically supply the necessary supplementary air, and so keep the mixture more or less perfect at all speeds.

Thus the first difficulty in the way of improved governing has been overcome. See Carbureter.

Another difficulty, commonly called "hunting," applies only to the centrifugal governor, and will be dealt with farther on.

We will now describe under five heads the various systems of governing, beginning with the oldest (which is still partially in operation) and concluding with the most modern. The following are the systems: 1. By varying the timing of the spark. 2. By retention of the exhaust gases. 3. By retention of part of the exhaust gases. 4. By complete cut out of the fuel supply. 5. By reduction in the volume of fuel.

(1) By Varying the Timing of the Spark.

This system of governing is almost out of date, except in combination with the throttle. It is an axiom which our readers may take for granted, that to get the best results from the expansion which follows the firing of the charge in the combustion chamber it is necessary that the mixture should be perfect, the compression at its maximum, and that the force of the expansion should be applied just as the piston begins to descend. The power of the explosion can, therefore, be varied by retarding the ignition so that the firing takes place when the piston has descended to a greater or lesser extent in the cylinder. The disadvantages of this system are as follows: It is wasteful, for two reasons; first, because the period during which the power is exerted is reduced, and secondly, because the compression becomes less as the piston descends, and consequently the force of the expansion becomes less also. It overheats the engine because combustion is not completed by the time the exhaust valve opens, and therefore a flame rushes through the exhaust port. For the same reason it damages the exhaust valve, rendering frequent grindings necessary. Finally, on account of the imperfect combustion, the plugs and valves are fouled. Even in the case of single-cylinder cycles, a throttle valve is fitted, and the driver should endeavor to check his pace by means of this valve and the exhaust valve lifter rather than by retarding his ignition unduly. Of course, if it is necessary to travel at a crawling pace, as in traffic, he may have to retard his ignition to the utmost; but under normal conditions the throttle valve will be found to regulate the pace satisfactorily.

In most cars fitted with mechanical governors the ignition is so arranged that it can be advanced or retarded, but on no account should this method of reducing the force of the explosion be made use of solely for governing purposes. The driver will find it good practice to keep his ignition lever for the most part in a normal position. If, however, he is running his engine at its very topmost speed, he may advance the ignition so as to insure the explosion taking place when the piston is in the most favorable position. On the other hand, if the engine is running slowly he may retard it to a slight extent, but not sufficiently to seriously affect the compression, or to interfere with the perfect combustion of the charge.

(2) By Retention of the Exhaust Gases.

A few years ago this system was in almost universal use. Now it has become obsolete, but at the same time there are some cars on the market which are governed in this manner. Briefly, it consists in temporarily preventing one or both exhaust valves from opening when the speed of the engine reaches a certain point. As a result, one or both combustion chambers remain full of the products of combustion, and no fresh charge can be admitted. The engine will consequently slow down until, at a certain pace, the exhaust valve opening mechanism comes into operation again, the products of combustion are ejected, and a fresh charge or charges taken in.

(3) By Retention of Part of the Exhaust Gases.

This is the method adopted on the DeDion car, and it has been found satisfactory. It consists in reducing the lift of the exhaust valve by a mechanism which we will presently describe, and is, as a matter of fact, a very effective system of throttle governing. By the operation of a pedal the driver is able to reduce the lift of the valve within certain limits, and consequently prevent the whole of the exhaust gas from escaping. As a result of the cylinder being partially occupied by these exhaust gases, the suction is less powerful, and consequently a reduced charge of mixture is admitted to the

combustion chamber. The compression, however, is still maintained at its maximum, and therefore the system makes for economy. The engine is not overheated, as it would be if a full charge were admitted, and the combustion is good. Some authorities maintain that the mixture which enters the combustion chamber under these circumstances has not time to mingle with the waste products of the previous explosion, but the personal experience of many owners shows that the system is successful. Both noise and power are reduced instantaneously, while the moment the foot is raised the car bounds forward once more.

Fig. 1 gives a good idea of this system. E is the cam which lifts the exhaust valve, of which the plunger F is shown. This

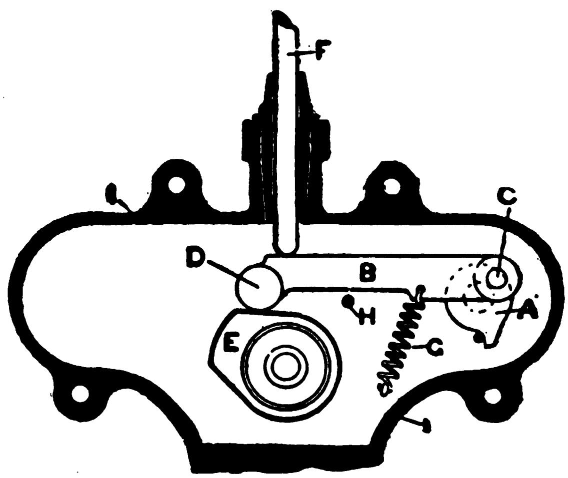


FIG. 1.—THE DE DION EXHAUST VALVE REGULATOR.

cam does not act directly on the stem of the exhaust valve, but on the roller D at the end of the rocker B which is pivoted eccentrically on a disk A, which in turn is moved by the foot-controlled pedal. Normally, the eccentric A is so placed that the rocker B is at its highest point, and thus at each revolution of the cam the exhaust valve is opened to its fullest. When the pedal is depressed, however, the disk A is revolved from right to left, thus pushi[illegible] the rocker B forward so that

the cam E reaches the roller D, at a later point in its revolution, and therefore a lesser lift is given to the plunger F. According to the amount of motion given to A the lift of the exhaust valve is regulated. H is the stop on which the rocker B rests when at its lowest, and the spring G maintains rocker B in position. In the diagram, the cam E is just leaving the roller D.

(4) By Complete Cut-out of the Fuel Supply.

In the Lanchester 2-cylinder engine the governing arrangement is obtained by suspending the action of the feed valve, or preventing the engine from using a fresh charge of gas. This is effected by a type of hit-and-miss governor, which depends on inertia for its action. This method of governing is remarkably sensitive, and the sluggishness common to many of the other forms of governor is absent.

(5) By Reduction in the Volume of Fuel.

This is the most usual system of governing. There are several ways in use by which the reduction of the fuel charge necessary to provide the governing effect may be accomplished, including the following:

(a) By obstructing the inlet pipe by means of a throttle valve.

(b) By increasing the tension of the inlet valve spring, or the equivalent of the spring.

(c) By reducing the lift of the valve.

(d) By reducing the time of opening.

(a) By Obstructing the Inlet Pipe—Governing by obstructing the inlet pipe is familiar to all motorists. It consists in arranging a butterfly valve or a rotating plug valve in the pipe, which are actuated directly from the governor. The principle of this device is easily followed. It depends for its action on a governor fitted on the half-time shaft, which is fully dealt with under the heading Governor.

Fig. 2 illustrates the system as adopted for the reduction, or cut off, of the fuel supply. A is the half-time or two-to-one shaft of the motor, and mounted upon it is the gear wheel

B, which consequently revolves with it. O, O are the governing weights which are attached to B by arms working freely on studs, and which have continuations Q, Q at right angles to them. The ends of Q, Q bear against the sleeve C, which is free to slide on the shaft A when pressure is applied, but which is normally pushed against the arms Q, Q by the spring S.

P is the spring connecting the weights O, O, and tends to draw these weights towards each other. In the chamber or pipe Y is a butterfly throttle valve, which governs the admission of the mixture to the combustion chamber. The ob-

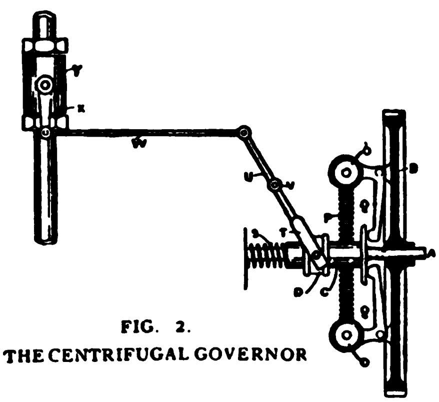


FIG. 2.
THE CENTRIFUGAL GOVERNOR

ject of the governor is to control this butterfly valve, which it does in the following manner:

The spring S is so adjusted as to hold the sleeve C against the arms Q, Q, until the engine reaches a certain pace, while, by means of an accelerator in the shape of a hand or foot lever, the spring S can be assisted to hold back the sleeve C. Now, so long as this sleeve is held against the arms Q, Q, the governor does not come into action, and the throttle valve remains fully open. When the engine is started, the gear wheel B, and with it the weights O, O, revolve, and centrifugal force tends to make the latter fly outward, a tendency which is resisted by the spring P. As the speed of the engine increases, however, the centrifugal force overcomes the resist-

ance of the spring P; the weights fly out, and the arms Q, Q, press against the sleeve C. A further increase of speed causes increased centrifugal force, which, at a certain point, overcomes the resistance of the spring S, the sleeve C moves along shaft A, and the throttle valve begins to shut, and so reduces the charge admitted to the combustion chamber. This has the effect of slowing the engine slightly, and the throttle opens again, either partially or wholly, according as the driver operates his accelerator.

The illustration plainly shows the general principle on which the centrifugal force is conveyed from the governing weights to the throttle valve. The arms Q, Q push the sleeve C, the sleeve C actuates fork T on the rod U, which is pivoted at V. The rod W connects U to the throttle lever X, and so the butterfly valve inside Y is operated.

Fig. 3 completes the explanation of the system of governing on the throttle which is the most commonly used in one form or another. A plate of metal, circular in shape, is at-

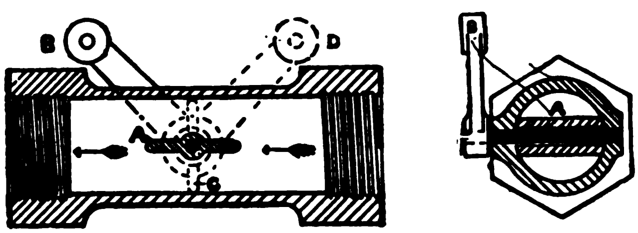


FIG. 3.—THE BUTTERFLY THROTTLE VALVE.

tached to a spindle passing transversely through the valve. In its extreme position this plate completely closes the pipe. The maximum opening is obtained when the "butterfly" is parallel with the axis of the valve chamber, as seen in the illustration. Adjustment between these two points regulates the supply of gas to the engine. The engraving shows a butterfly valve in section. In the longitudinal section the disk A is seen parallel to the center line of the bore of the valve. The spindle to which the disk is fixed is seen in the view of the end section, which also shows the actuating lever B. The

dotted lines as at C and D show the valve closed and the relative position of the actuating lever.

Hunting—This brings us to the second difficulty already alluded to, which motor manufacturers have had to face in their endeavors to produce a flexible and silent engine. We refer to the condition called "hunting." By this term is meant the sudden burst of speed caused in some cars when the governor balls fly back to their normal position and allow the throttle to open fully, followed by the no less sudden drop when the increase of speed causes the governor to come suddenly into operation again. This peculiarity is due to the fact that the centrifugal action which gives motion to the governor weights does not follow the straight line law. In other words, supposing the engine to be running at from 300 to 400 revolutions, and the outward movement of the weights against the action of the spring or springs to be ½ in. for an increase of speed of 100 revolutions, the motion for a similar acceleration—with the engine running from 1,000 to 1,100 revolutions—might be only ⅛ in., seeing that not only the angle of the weights about their fulcrum, but the strength of the spring, has altered as the speed of the engine increased. In some engines this action is very pronounced on the lower speeds, and causes the car to rush forward and check again with a suddenness which is very disconcerting. The subject is further dealt with under Hunting, and remedies suggested.

In some cases no mechanical governor is fitted, but the throttle is worked by hand, in combination with the ignition, and so varies the speed of the engine.

(b) By Varying the Tension of the Inlet Valve Spring—This system has been in use on the continent of Europe, but is now almost obsolete there. It operates by automatically adjusting the inlet valve spring.

(c) By Reducing the Lift of the Inlet Valve—This is an effective and economical method. The modus operandi is simple. The cams for lifting the inlet valves are mounted on a steel sleeve, which is capable of [illegible] along the half-speed shaft of the motor. Th[illegible] from